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SURGERY OF THE

THORAX AND ITS VISCERA

Symptoms, Diagnosis, Indications and Treatment

CONTAINING SIXTEEN ILLUSTRATIONS

BY

BENJAMIN MERRILL RICKETTS

PH.B., M.D., LL.D., F.A.C.S.

Member American Medical Association; (House Surgeon N. Y. Skin and Cancer Hospital, 1884-5); Ohio State Medical Society; Western Surgical and Gynecological Association; International Medical Congress, 1887; International Assn. Railway Surgeons; Miss. Valley Medical Assn.; Cincinnati Academy of Medicine; Honorary Member Medical Society State of New York; Honorary Member St. Louis Medical Society; Fellow New York State Medical Association; Member Societe Internationale de Chirurgie; American Urological Association; American Proctological Society; Cincinnati Society of Natural History; Pan-American Medical and Surgical Congress; Honorary Professor of Surgery of the Thorax and Its Viscera; Barnes and American Medical Colleges; National University of Arts and Sciences, St. Louis, Mo.; American Assn. for Thoracic Surgery, and Clinical Congress of Surgeons of N. America

Author of Volumes: What To Do in Case of Accident; Surgery of the Prostate, Pancreas, Diaphragm, Spleen, Thyroid and Hydrocephalus, Surgery of the Ureter, Surgery of the Heart and Lungs, Cloacal Morphology in Its Relation to Genito-Urinary and Rectal Disease; Founder and Director of the B. Merrill Ricketts Experimental Surgical Research Laboratory, Cincinnati, Ohio, etc. etc. etc., etc.

CINCINNATI

1918

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THIS VOLUME

IS DEDICATED TO MY DECEASED BROTHERS,

DOCTORS EDWIN SAUNDERS RICKETTS

and

JOSEPH VINCENT RICKETTS,

WHO WERE MY MOST INTIMATE ASSOCIATES IN SURGERY

AND ALL THINGS ELSE;

TO MY DEVOTED STUDENTS AND ASSISTANTS

and to the

PHYSICIANS, SURGEONS AND SCIENTISTS

WHOSE SCHOLARLY ATTAINMENTS

HAVE MADE IT POSSIBLE.

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INTRODUCTION.

Lectures beore the students of the Medical Department of Barnes University, the American Medical College, National University of Arts and Sciences, and various medical societies, form the basis for this volume.

The object in presenting this work has been to make it an auxiliary to my work on "The Surgery of the Heart and Lungs," a volume of 600 pages, published in 1904. Since then many advances have been made in both technique and appliances, until now many seemingly bold predictions contained within that publication have been realized. Much of the subject-matter represents the thought of many of those interested in their respective subjects, and there has been no inclination to refrain from giving them due credit. In a few instances entire papers have been reproduced, others freely quoted, and many given but passing mention, but with all consideration has been given because of the most advanced thought which they contained.

Bibliography has been classified, chronologically arranged and appended to the various chapters, that it may be more readily referred to. It is difficult to transcribe bibliography many times without more or less imperfections; for this reason it is not perfect, but is sufficiently so for all practical purposes.

My appreciation is hereby tendered to Mrs. Dora W. Harris for the devotion and competency displayed in transcribing much of this work, and to Miss Bertha Bahlman for assisting in the arrangement of the bibliography. It is also my pleasure to express my gratitude to my assistant, Dr. D. D. DeNeen, for arranging a part of the chapter on the esophagus.

Since this work was completed, thoracic surgery has advanced by leaps and bounds because of the opportunities offered by the multiplicity and great variety of injuries to the chest and its contents. Such opportunities have never before and probably will never again be afforded, and were it possible within the

allotted time for this work to appear under cover, a chapter would be added dealing with its newer phases; but its enormity precludes the possibility of giving it consideration at this time. Therefore, the newer phases of this subject will be left for those whose fortune it has been to observe and deal with wounds of the thorax and its contents that have occurred in this great war. Suffice it to say that the principles involved in the predictions made in my work on "Surgery of the Heart and Lungs" (1904) to the effect that surgical invasion of the thorax would be made as fearlessly as that of the abdominal cavity and without the use of antiseptics has been proven and are being used generally by army surgeons.

Concerning the ethics of plagiarism, the following remarks are copied from the New York *Times*, August 13, 1911:

"It is next to impossible to say anything that some one has not said before.

"That fact remains why so few authors have escaped the charge of plagiarism.

"If a good thing can be repeated so as to make a new appeal, it justifies itself, even though it may open the door to the charge of imitation.

"The deliberate appropriation of the sayings of another in flagrant violation of the ethics of the quotation marks, is a cardinal literary sin, but few authors or composers of worth consciously steal the thoughts of others.

"Most charges of plagiarism are unjust, and he who makes them should have a care that he is not himself as guilty as the one he accuses.

"Plato condemned Homer for imitating earlier poets, while he himself borrowed from Homer.

"Socrates appropriated from Zeno, and Virgil did not hesitate to utilize the thoughts of earlier writers.

"Even Shakespeare, Lowell says, 'scarcely ever scrupled to run in debt for his plots,' and Johnson borrowed the words of his most beautiful song, 'Drink to me only with thine eyes,' from Philostratus.

"The plagiarist, therefore, despite his offense, finds himself in good company.

"In his caustic criticism of plagiarists, Poe admits having appropriated the caption of his essay from Dionysius.

"Few are the speakers, writers or thinkers, who can

with good grace charge any of their contemporaries with plagiarism.

"Yet to borrowed ideas literature owes much, for he who can present a thought in better form than he found it has done a service to mankind. The sin of plagiarism lies in the appropriation of a well-expressed idea and making poor use of it.

"Chaucer's influence in literature is incalculable, yet Chaucer, as Emerson says, was 'a huge borrower.'

"Mirabeau, we are told, felt that the things which his presence inspired were as much his as if he had said them.

"Possibly Adam was original; no one else has been wholly so.

"The inventor achieves success by utilizing the thoughts of those who have gone before.

"Howe was not the first to dream of the possibilities of the sewing machine. Madersberger, Adams, Dodge and Thimonnier had preceded him.

"Should Watt have abandoned his study of applied steam, which resulted in his invention of the steam engine, because others had dreamed dreams before him?

" 'Invention, strictly speaking,' says Sir Joshua Reynolds, 'is little more than a new combination of those images which have been previously gathered and deposited in the memory.'

"Great would be the sacrifice were we to surrender that dear American classic, 'Rip Van Winkle,' for no other reason than that Irving borrowed it from the German.

"Longfellow found the idea of his 'Wayside Inn' tales in the 'Canterbury Tales,' and Tennyson took many of his themes from less attractive writings than his own.

"Shall we condemn Wagner for going to the old legends for his operas? Rarely is an opera produced in these days, when we are so hungry for new things, that the critics do not pronounce the music 'reminiscent.'

"Genius may reach greater heights than talent, but it generally uses the talents of others for stepping-stones. No man, however talented, ever reached the top without profiting by the experience of others.

" 'Newton,' said Matthews, 'could never have been Newton without the labors of Kepler.'

"Pope Gregory the Great burned the works of Varo,

a writer of prodigious erudition, from whom St. Augustine had borrowed profusely, that the latter might escape the charge of plagiarism.

"Balzac borrowed bodily, in one of his novels, an entire chapter from Bulwer's 'The Disowned,' while Bulwer, in turn, helped himself to many good things from Hazlitt, Mrs. Inchbald, Schiller, Richter and others.

"The tune of 'America' is taken from 'God save the King,' and Mrs. Howe's grandiloquent 'Battle Hymn of the Republic' sings itself to the air of 'John Brown's Body.' The poem 'The Beautiful Snow,' has no less than eight poets claiming its authorship. Here must be seven cases of plagiarism.

"Since so few of us escape the taint, we should be more generous in our judgments and less generous with our charges.

"Let the imitation be better than the thing imitated, and the offense will be thereby condoned."

B. MERRILL RICKETTS.

Northwest Corner Fourth and Broadway,
Cincinnati, Ohio.

May 20, 1918.

Reprint from The Lancet-Clinic, October

CIVILIZATION YESTERDAY—TO-DAY—TO-MORROW.

B. M. RICKETTS, M.D.,

CINCINNATI.

LADIES AND GENTLEMEN: Permit me to say that I do not appear before you without more or less timidity. I realize that I am associated with masters in the art of physic, and all that is required to make the most aggressive and progressive people that has ever inhabited the earth. There is no sentiment in science because it deals with facts only.

To-day we are enjoying the hospitality of a city that was founded by Augustus and Pierre Chouteau, 1739-1849. Much of the sentiment which permeates your profession, and has caused much of the great advance in both medicine and surgery, is an inspiration from the deeds of those self-sacrificing pioneers. The every-day affairs of building the metropolis of the Mississippi Valley, which has so recently celebated its one-hundredth anniversay, were adjuncts to your renown.

Augustus, born in 1739, died, 1829, and Pierre, born 1749, died, 1849. The former lived to the age of ninety and the latter one hundred years. Surely they saw much progress, but what of progress since their taking?

Here was spent a most useful and honored career in the person of John T. Hodges, that master surgeon, whose name is associated throughout civilization with fractures. Bernays, the brilliant and versatile scholar, among the first to present and practice asepsis and the modern principles of surgery in America.

Love, the prince, beloved and admired by all for his ability and affection for his fellow-craftsmen; Laidley, the immaculate, known for his energy and

skill; Bauer, renowned for his excisions of the hip joint, and as being the originator of the plaster jacket, and Mudd, the ever faithful gentleman of intellect.

Though their passing was untimely, they have lived in the most progressive historic period, and they represent but a handful as compared to the number of notable characters who sleep beneath the bosom of your soil. As for those remaining, they represent the most modern and progressive men in medicine and surgery, and they have to offer the newer and most substantial teachings with an equipment of every kind unsurpassed.

Students in the Mississippi Valley are as well qualified to enter upon the study and practice of medicine and surgery as those of any other territory.

These conditions and environments should attract them even to the metropolises.

After dealing with these few personalities, permit me to refer to the founders of the science and art of medicine.

The earliest known physician was Sokhit-Ni-Onkh, a priest, who lived 5,500 years ago. His tomb, situated at Sakkarah, in Memphis, was but recently discovered. Its door was a slab of limestone, weighing fourteen tons, and can now be seen in an excellent state of preservation in the Museum of Antiquities in Cairo. There were no physicians in those days outside of the priesthood. His title was Senau, meaning wisdom or knowledge, and here, as elsewhere, was represented by an arrow with a broken shaft, because the word arrow was phonetically the nearest to the word wisdom.

Compare the Arabic Hakeem, which was an etymology similar to Senau, and the English word wise, wit, witch and wizard, which are derived from the old English verb wit, to know. Medicus comes from Medh, to be wise.

On the stela the physician stands with a sceptre in one hand and a wand in the other, sometimes alone, sometimes with his wife standing behind him, and his name is always written plainly above his head.

The laws governing surgery at that time, though a

bit more severe, do not differ materially from those of to-day. The following were among the earliest two hundred and eighty Babylonian laws.

The discovery was made at Susa, Persia, December and January, 1901-1902, by M. de Morgan's French excavating expedition. The monument on which the laws are inscribed is a stile of black diorite eight feet high, completely translated by Dr. Hugo Winckler in Hebrew.

215. If a physician make a large incision with operating knife and cure it, or if he open a tumor (over the eye) with an operating knife, and save the eye, he shall receive ten shekels in money.

216. If patient be a freed man he receives five shekels.

217. If he be a slave of someone, his owner shall give the physician two shekels.

218. If a physician make a large incision with operating knife, and kill him, or open a tumor with operating knife and cut out the eye, his hand shall be cut off.

219. If a physician make a large incision in the slave of a freed man, and kill him, he shall replace the slave with another slave.

220. If he should open a tumor with the operating knife, and put out his eye, he shall pay half his value.

221. If a physician heal the broken bone or diseased soft part of a man, the patient shall pay the physician five shekels in money.

222. If he be a freed man he shall pay three shekels.

224. If a veterinary surgeon perform a serious operation on an ass, or on an ox, and cure it, the owner shall pay the surgeon one-sixth of a shekel as fee.

225. If he perform a serious operation on an ass or ox, and kill it, he shall pay the owner one-fourth of its value.

226. If a barber, without the knowledge of his master, cut the sign of a slave not to be sold, the hands of the barber shall be cut off.

227. If anyone deceive a barber and have him mark a slave not for sale with the sign of a slave, he shall be put to death and buried in his house. The barber shall swear, "I did not mark him wittingly," and shall be guiltless.

While some of these laws were rigid, there is a medium of justice displayed in them.

During all of this time records of work done were made upon tablets and parchment that they might be preserved for reference. These were collected from time to time and deposited here and there in the larger centers of habitation. The safety of these libraries was in constant jeopardy, because of the instability of governmental institutions. However, a few were preserved for several hundreds of years, among them the Alexandrian, Nippurian and Chinese libraries.

The Alexandrian library was probably the largest and most important, and its destruction to be more deplored. It was destroyed by Omar, the third Mohammed, by fire, but not as is generally believed, as a whole, as the various manuscripts were used to heat the 4,000 baths of the city for several months, and then Omar offered the Koran or sword after the siege.

The Nippurian library contained 130,000 tablets pertaining to literature and history of many generations.

The Chinese library was collected after many centuries, and, like all libraries of that empire, was destroyed by fire by Hwangti, 213 B. C. It was he who built the great wall. He preserved all the literature pertaining to medicine and agriculture, but hated the literary class because they caused so many dissensions with the populace, and, as a result, executed 500 of them, imprisoned thousands, and banished many more.

Anthony gave Cleopatra the Pergamese library, containing 200,000 volumes.

The laws and the destruction of libraries probably retarded progress, but they did not prevent it. Though it is stated that blood-letting and setting of fractures

were unknown in China about 1800 A. D., the latter has probably been done since the creation of man.

One has but to read from the Talmud to be convinced that many requirements were met concerning the physical man. The following were but a few of many contained therein mentioned:

1. Talmud Sabbath, fol. 150 a.: "If a new-born child has no breath, the breath shall be blown in and it will begin to breathe."

In the same place: "If a child is born weak so that it can emit no sound, then smear it with the umbilical cord" (to keep up the circulation of the blood).

At the same place: "If a child can not suck, hold a plate of warm coals so that its mouth shall grow warm."

The Talmudists knew of the Caesarean operation. See Talmud Sanhedrin, fol. 45 a.

Also the removal of the spleen, Talmud Sanhedrin, and Aboda Sara 44.

The removal of the fetus is mentioned in Bechoroth 46 a, and in Nidda, 28 a.

Nidda, 21 b, an operation is spoken of, of the insertion of a tube in the mouth of the womb, to further menstruation.

So also to remove semen in the urethra by means of wife or a blade of grass. Nidda, 22 a.

Venesection is mentioned often, *e. g.*, Gittin, 70; Baba Bathra, 58; Jebamoth, 88; Sabbath, 129. It is regarded as exceedingly injurious to palpate (touch) the wound made by the operation. See Sabbath, 108, b. "The hand that touches such a wound deserves to be cut off."

In Taanith, 21 a, Dr. Abba is mentioned who operated on men and on women and had separate rooms for these "for sake of decency." He also provided aprons for the patients, and he arranged that the patients did not have to expose their persons.

In Kethuboth, 20 b; Kerithoth, 15 b; Semachoth, 4, 28, there is mention of amputation of arms and legs.

In Sabbath, 66 a, cripples were operated on and artificial limbs are provided.

In Jebamoth, 76 b, a Dr. Marbar Rab Assi operated on the penis for fistula.

In Aboda Sara, an operation on the præputium is mentioned.

Bandaging the head, after an injury, and the treatment of a broken bone are mentioned. Sabbath, 147.

The reposition of dislocated maxilla is spoken of in Aboda Sara, 29.

Manipulation in dislocation of the cervix is spoken of in Sabbath, 66 b.

Hernia and its treatment (operatively) is mentioned. Sabbath, 66 b.

In Chullin, 56 a, a case of a damage to the abdomen is cited. The intestines are said to have protruded.

The son of the patient was brought forth and it was made believe as if the surgeon proposed to kill the boy. The patient became frightened and, breathing heavily, the intestines followed inwardly.

(These references were kindly supplied by Rabbi Greenman.)

In the Ebers papyrus, 1600 B. C., there is a list of 16 abdominal, 11 urinary, 10 rectal, 6 chest, 7 heart, 7 vascular, 30 eye, 6 ear, 4 nose, 3 head and 1 in diseases. It reports a list of 700 medicines, and among prescriptions 74 hair tonics. The ladies had their medicine chests, which have come to our time. The Hebrews were great imitators. They brought many things out of Egypt. Sate says that in the temple of Belus was the ark, the table of show bread and brazen laver supported by brazen oxen, and the columns Jachin and Boaz of King Solomon's temple had their prototypes at Nippur and were repeated in the Phœnician temples long before they reached Solomon." (Kinsman.)

During the first 1,300 years A. D. there can be but little found pertaining to what was known and done during that period. Since that time, however, records become more numerous, indicating the beginning of a new era of progress which seems to have had no bounds. Laws and customs were materially changed, so that more or less of distinction was made between

the rights of the surgeon, the barber, the veterinarian, midwife and apothecary. These professions were pretty much upon the same basis with respect to rights and practice until about 1800 A. D., but throughout all time the surgeon has been given preference.

While empiricism has always been more or less recognized, it did not receive its death knell until during the fifteenth century, when Paracelsus, born 1493, convulsed the world with his advanced medical opinions. He and Van Helmont reformed medicine. The Galenical physicians refused license to those of chemical medicine. This instituted an examination of candidates. The rejected ones were called "Lewd Empirics." The Galenical school lost and chemical won. The latter were allowed to practice in London and Paris without license.

The Galenical members left the college during the plague, leaving the chemical men to care for the plague. After the plague the Galenical men returned, and the law persecuted the chemical men.

In 1721 the prosecution of Mr. Rose, an apothecary, for practicing physic, caused him to carry it to the House of Lords, which favored him, so that medicine could be sold to the sick without a prescription from a physician.

The crude manner of treating certain diseases at that time is shown in the following bit of interesting information related by Vasco Da Gama: While navigating around Africa, 1498, his men became afflicted with ulcerated gums to such an extent that teeth were many times lost. Each person afflicted washed his mouth with his own urine, which was supposed to be a means of cure. (*Great Events by Famous Historians*, Vol. 18, p. 318.)

Those who had the courage to operate upon living beings must have had some knowledge of anatomy, even though death was the penalty for any attempt to dissect the dead human body. It was not until 1540 A. D. that any law was passed permitting the dissection of the dead human body. It permitted the united companies of barbers and surgeons to have

yearly the bodies of four criminals to dissect. Notice that barbers are mentioned first in this paragraph.

On June 30, 1703, the apothecaries induced the Prince of Denmark to issue the following order: "I do desire and direct you to order the surgeons of his majesty's ship to furnish and provide their chests at the common hall of the Company of Apothecaries, and not in any other place, said company having assured me that they will furnish both good and cheap."

There was great trouble at this time between the profession and apothecaries. Groceries sold more physic than apothecaries.

The order by the prince is one of the first official attempts to separate the apothecary from the grocery shop.

Not until about 1800 A. D. were graduates in physic generally employed for accouchement. Since that time pregress in both medicine and surgery has been rapid. In America were founded the great underlying principles for the practice of obstetrics, and she continues to maintain that honor; she also prides herself on having possessed the first organized dental college, though dentistry was practiced before the destruction of Pompeii, dental instruments having been found in her ruins. Many obstetrical and surgical instruments have also been found there, more or less perfect in their construction.

What has transpired during the last century that pertains to the medical profession? The answer might well be, What has not transpired? For surely the science of medicine and surgery pertains to all things incident to the process and progress of civilization. There is not a vocation or any condition in which any form of animal, vegetable or mineral life does not directly concern it.

The events have been too numerous to mention and their importance too great to realize.

It might be well, however, to mention a few of them, that due respect may in a measure be shown. Especially is it appropriate to recall the work of the much respected Beaumont, who resided in this city. It was he who first discovered the fundamental prin-

ciples of the physiology of digestion. The names of Beaumont and Alexis St. Martin, his subject, will ever stand out in bold relief in the history of American medicine.

Not only have new operations been discovered, but old ones have been made more perfect.

Neoplasms and pathologic tissue in any organ of the human body are now at the mercy of surgery.

Injuries of almost any character to any human organ or tissue may now be repaired by surgical methods with a reasonable degree of assurance of recovery.

Foreign bodies and concretions, wherever found in the human economy, are removed without fear of deadly results, with but a few exceptions.

One or more of the various glands, both with and without ducts, may be removed in their entirety without disaster.

Deformities, congenital or acquired, are made to give up their unsightly characteristics, and take on features more consonant with the laws of nature.

The art of grafting epithelial structures has been made so perfect that there are hardly any limitations to what can be done.

Transplanting and implanting have been so perfectly accomplished that arms and legs may be transferred from one human being to another and function retained.

The thyroid, spleen and pancreas may be removed and replaced with the same kind of tissue from another without loss of function.

All of the ovarian tissue may be removed and replaced with ovarian tissue from another, so that impregnation may occur.

Sero-therapy has caused many diseases to become mitigated somewhat, many times to absolutely surrender their deadly character.

Yoghourt, the Bacillus Bulgarius of the Himalayan buttermilk, is said by Metchnikoff to be a deadly enemy to the Bacillus Typhosus. The two cannot exist side by side within or without the alimentary tract.

It would, therefore, seem that lactic-acid bacilli are a prophylaxis for typhoid fever.

Smallpox, bubonic plague, cholera, yellow, typhoid, typhus and malarial fevers, and many other diseases, are now at the mercy of the sanitarian, requiring, it would seem, only a few more years to bring them under absolute control.

Among the newer antidotes is permanganate of potassium for opium poisoning, and alcohol for carbolic acid poisoning.

Electricity has been applied therapeutically in many ways more or less successfully by means of light, heat and motion.

The X-ray by its wonderful revelations in localizing fractures, foreign bodies and pathological lesions, has now become a fixture in the medical and surgical armamentarium.

Radium is yet to unfold many of its mysteries, in the meantime revealing marvelous things.

The telegraph, only seventy years in existence, has made the whole world akin, requiring only a few minutes to carry a thought around the world. Photography by telegraphy is now so perfect that an image may be recognized thousands of miles away.

The telephone, of much more recent discovery, enables one to recognize a voice across any continent or beneath any body of water.

The wireless telegraph is not without its mysteries. The dangers and lonesomeness of sea voyage are many times abolished by its use. Craft upon the high seas propelled by wind, steam or electricity, may communicate with unseen vessels and continents by the influence of electricity upon the strata of atmospheric ether.

Vessels unmanned may be definitely directed upon bodies of water by it and the gyroscope to a very considerable distance.

All forms of transportation on the earth, through the earth, or above the earth and upon the water, beneath the water or above the water can now be done by means of electricity, gasoline and compressed air, for motor purposes.

The wind, the treadmill and service elevator for motor force have been supplanted by gas, steam and electricity.

Implements of war, so much improved by Dr. Gatling, have now been developed to such a degree that they are veritable death-dealing machines. The various improved explosives add much to their destructiveness.

All methods and implements of war upon land and sea have been changed many times during the last century, until now the propriety of war is questioned because of their deadly effect.

Submarine navigation has not only been accomplished, but with reasonable safety, and the ocean can now be explored by the presence of man to the depth of 160 feet.

The enemy may be attacked unseen by day as well as by night.

The caisson, which was first demonstrated in the construction of the great bridge spanning your mighty waters, has made it possible to perform engineering feats that could not otherwise be performed, until now it is universally adopted.

Constructing public highways beneath great bodies of water, both by excavation and imbedding metallic tubes, seems yet in its infancy, there being no seeming impossibilities.

The construction of railroads across valleys, upon the plateau, through mountains and over large bodies of water, has been so well perfected that the great American continent may be traversed in fifty-two hours.

One of the most important discoveries was the cotton gin by Whitney. It had more to do with the enormous production and cheapening of cotton goods than any other device concerning its manufacture.

The printing press is of American origin and has had much to do with the civilization of man. Its use was first denied in the New England States because printed matter was supposed to be against the best interests of religion. It was finally used for printing religious tracts for the Indians, and then it fell into

the hands of Franklin, who adopted it as a means of printing the *Saturday Evening Post,* which continues to be delivered to our doors.

The production of new varieties of fruits and vegetables has been so extensive that the identity of the original ones is many times destroyed. Bulbs, vines and trees have, in many instances, been made to double their product, at the same time bearing more delicate and perfect fruit.

In no kingdom is the diversity of beauty better demonstrated than by the art of grafting and mixing of pollen among flowers. There are already about ten thousand of the genus chrysanthemum alone.

Melting wood fibre has now been accomplished by heat in a vacuum with the exclusion of oxygen. An entire tree may be melted in a retort and moulded into sows and pigs as the metals are moulded. This process will, in due time, be cheapened, so that the larger trees will not be necessary, because those smaller may be melted together, with vines and saplings, to answer almost any purpose. Think of it, there will be wood foundries as we now have iron foundries!

Each of the four divisions of the sub-kingdom vertebrata has been made to feel the influence of the skillful touch of man, for they have many times been made to bring forth offspring twice in twelve months, this having been demonstrated in the hog and sheep. Some animals, especially the horse, have been so skillfully bred that certain markings may be expected at the time of foal. Crossing the zebra with the Shetland pony has produced an offspring with the docility of one and the beauty of the other.

Fowl of various kinds have also been made to undergo many changes in breeding, while in some of our western waters may be found several varieties of trout, which are the result of domestication.

The artificial production of ice was first done by Dr. Garrie, 1851, in the small village of Apalachicola, Florida, where may be seen a monument erected to his memory. Since then it has become the universal means of supplying ice in all climates throughout the

year, that both those in health and disease may be benefited.

The discovery of general anesthesia and its first use in man, was the greatest advance in surgery, and now, by local anesthesia, still greater advances are made.

The flight of the bird has now been so perfectly imitated that space no longer defies the intrusion of man. He soars aloft and over channels separating mighty nations that have met in deadly combat.

Discovery of continents and new bodies of water has always been the ambition of men.

The mysteries of the source of the Nile and Congo rivers and the waters of the Victoria Nyanza are now revealed to the everyday tourist.

The lens, discovered many centuries ago, but not put to practical use until during the seventeenth century, has made it possible to discern not only the minutest terrestial, aquatic and atmospheric objects, but planetary bodies, and possibly their inhabitants one hundred million of miles distant. If a telescope can be constructed to view objects so far away, why can not one be constructed with that capacity many times multiplied? This is not an impossibility.

It would be difficult to place any limitations upon not concern.

The soil and cultivation for the production of animal, vegetable and mineral fabrics and the water consumed in their cultivation and manufacture is best served by the use of this instrument.

Correct values are placed upon all by its use. It has been proved to be one of the fundamental principles in the great advance in civilization.

Indeed, the lens may yet be the means of supplying heat, light and motive power by condensing the rays of the sun and drawing them from a central storehouse.

Recent demonstrations upon the Hudson in honor of Fulton have brought forth interesting facts to dispute the priority of Fulton's use of steam for navigating purposes. While the honor is probably justly his, Rumsey's exhibition of a steamboat before

George Washington, in 1784, must not be forgotten. That Fitch's steamboat of 1790 made a speed of eight miles an hour, and was in service for several months on the Delaware, there can be no question.

In no institution of life have modifications occurred more than in religion. There are now twenty-seven hundred and sixty-three languages and dialects. There are also twenty-seven hundred and sixty-seven religions. Some become stronger while others become weaker, following the law of the survival of the fittest.

Changes in the appearance of the earth's surface are eternal. What now constitutes the highest mountains, valleys, plateaus, rivulets and rivers were formerly beneath the ocean's surface, and that which now occupies the ocean bed, was at one time terrestial surface. This change will again occur, so that the land which we now occupy will be the ocean bed, and the ocean bed be the land which other generations, perhaps different in kind, will occupy.

All planetary bodies may change their form and course, one or more being destroyed to make the course and existence of those remaining safe and perfect.

The mysteries of death may yet be unfolded, this having already, in a measure, been done by resuscitating the heart's action two and one-half hours after it had ceased to beat.

The date and discoverer of the circulation of the blood will probably always remain disputed. While Harvey, 1578-1657, has thus been honored, the name of Caesalpinus, chief physician to Pope Clement the Eighth, will always be associated with it, because of the book he published at Pisa, on the first of June, 1569, entitled "Questionum Peripateticarum, Libra, V." In this book there is a passage which evidently shows that he was thoroughly acquainted with the circulation of the blood. (Medicine and Med. Mem., Vol. 1, p. 257.) He was the first to use the term, "Circulation for blood." Servetus, 1553, and Vesalius, 1555, established the true doctrine and exploded

that of Caesalpinus. Realdus Columbus suggested the pulmonary course of the blood in 1559.

A popular vote in France decided that Pasteur, Voltaire and Victor Hugo were the three greatest men that the country had ever produced. Think of it, not the name of a warrior, even that of Napoleon, was mentioned. Pasteur's discovery of the cause of sheep rot and the epidemic disease of the silkworm and their remedies has prevented the scarcity of wool and silk, kept them at a uniform and minimum price, and thereby made it possible for those of most moderate means to possess them.

Classical education was the ideal and was the object. In earlier times it was thought that there was nothing more to desire.

Science was, indeed, to be born, but it took on form and rapidly developed to become the ever-pervading thought in all professions and trades.

Medicine and surgery have not been alone in benefiting in the progress of civilization. One hundred years ago it was thought that there could be no further progress, that the form of government of that time was without question indeed divinely appointed, but time has shown that all could be, should be and has been changed, that each, like great educational institutions must be flexible and change as necessity may require.

The university teachings of one hundred years ago could ont be tolerated in a great measure, or be sanctioned for that of to-day; especially is this so with religion, law and medicine.

One hundred years is ample time to bring about changes in thought, customs and environments to such an extent as to necessitate changes in the subjects to be taught and ways and means of doing it.

The mysteries remaining in nature's hand for man to grasp are numerous, what they are, or when he will come into their possession remains not altogether for future generations but for those of us who are spared to revel in the unknown.

It may be when the earth is devastated of its forests and the fuel within its bosom, that heat, light and

energy may be obtained from electricity produced by the fall of great rivers, or from the gas made directly from the waters flowing within their channels.

The advantages in the study of medicine and surgery have been multiplied and remultiplied from year to year until the results are greater than ever before produced.

This is so, because there are no limitations placed upon medical education; it requires knowledge of all things. Some have more, some less; he who has more is the happiest, most useful and self-sacrificing.

I submit to you my effort as a token of appreciation for this great honor, hoping that something I may have said or done will aid you in solving some of the perplexing problems that may confront you. If I have failed to demonstrate that there are still other worlds to conquer and have not shown their possibilities, I shall always feel like that much-lamented Watson, who said, on taking leave of his class in Kings College, "That I have done as well as my slender ability, broken leisure and irregular opportunity would permit."

From THE LANCET-CLINIC, October 15, 1910.

THE NEWER SURGERY.*

BY BENJAMIN MERRILL RICKETTS, M.D., PH.B., LL.D.,
CINCINNATI.
Honorary Professor of Surgery (Heart and Lungs) in the American Medical College, St. Louis, Mo.

REVERSION is a law constant in all forms of life, especially that of animal life and all that pertains to it. This is demonstrated by the progress of any art.

Discovery may be knowledge of something that has existed of which there is no record, or it may be the discovery of something that has never existed. The art of surgery is not an exception to the rule. Oid methods are being rediscovered and new methods discovered. Many of each have and will become obsolete and remain so unless revived by accident or otherwise. The deductions from the achievements of the past must necessarily add to the development which will be governed by university teaching. The lessons to be drawn from the right of expression have but recently been thoroughly demonstrated at the seat of some of the principal governments of the world, showing that the free expressions of thought should be unlimited in order that knowledge may be progressive, especially in university teaching. The term "university" indicates this *per se*, and any institution which does not recognize this principle cannot therefore be called university. If the doctrines of an institution universal in character are displeasing, those displeased should seek one where teaching is more in keeping with their belief; but education then ceases to be universal.

Such attainments signify knowledge in its broadest sense—the knowledge of all things, whether for or

* An address delivered before the Tri-State Medical Association, at St. Louis, Mo., September 13-14, 1910.

against any doctrine or belief. This knowledge will advance the investigation for the cause of disease, and when its origin is discovered, sanitary and other remedial measures for its prevention or cure will be more intelligently employed.

The sacrifice incident to the discovery of its cause has been great, especially with bubonic, yellow, typhoid, typhus and tick fever; with none has it been greater than with these, the list of martyrs who have but recently made it being evident.

The elimination of corrupt morals and venereal diseases can only be accomplished by means of education in earlier life. Teaching sexuality must be thoroughly and generally observed. Not until its importance and the dangers of the diseases associated with it are made known, can they be avoided or made to become less frequent. Legislation has not accomplished this, nor can it be expected to do so, though with many other kinds of vice the law may be enforced with more or less satisfaction. Such a condition is to be deplored, but it is due to ignorance of a natural law upon which is based the very object of all social reform.

Laws that cause the misfortunes of individuals to be made public, especially those pertaining to the sexual relation, will defeat the very purpose for which they were enacted, because the unfortunate will conceal their affliction.

One infected by another holding a certificate of health has recourse upon the municipality issuing such a certificate, and the holder of such a certificate has recourse upon the one who has made known to the municipality the nature of such an affliction. If, however, the nature of the disease is concealed, the afflicted will appear again and again to be made familiar with the dire consequences of infecting others, and thereby conserve the best interests of the public.

Now that Ehrlich-Hata 606 — dioxydiamidoarsenobenzol has been discovered to be a specific for syphilis, the ravages of this disease may cease to exist. This is probably the greatest discovery ever made in sero- or chemicotherapy, but there should be no cessation in the effort to prevent this disease. The question is,

however, will sexual indulgence be increased or diminished as the result of the discovery of a remedy so certain and easily applied?

Brain.—Any portion of this organ is now subject to successful surgical attack. Vessels may be ligated, and neoplasms, foreign bodies, clots, serum, blood or pus may be removed. Only recently the pituitary body has been partially removed, with most gratifying results in two or three of the cases operated upon.

A mortality of 33 per cent. attending an operation for a disease hitherto unknown to be cured or benefited by any means whatever, is not at all discouraging, even though it be pioneer work.

Apoplexy.—Non-traumatic cerebral hemorrhage has not met with much surgical favor. Bnt is this to continue to be so because surgical benefits have not yet been recorded? Why should not certain forms of non-traumatic clots be removed successfully? Surely they are analogous to traumatic clots in their effects. Do not many emboli, thrombi, clots and infarcts occur in various cortical areas and cavities in and surrounding the brain, without any immediate or subsequent noticeable results?

The causes of apoplexy are supposed to be due to cerebral hemorrhage, thrombus, embolism or infarct, because all are intimately associated with it. Is it necessary to have extravasated blood within the cranial cavity to produce apoplexy? Will a thrombus or embolism or infarct always produce apoplexy without rupture of a vessel or the extravasation of blood or serum through its wall? Does the occlusion of a cerebral vessel by thrombus or embolus produce immediate apoplexy, or does it occur subsequently? If so, why does not the application of a ligature to any of the cerebral vessels produce apoplexy from embolism, thrombus or infarct? If infarct, why does not ligature of the vessel produce infarct? Does a *vis a tergo* produce rupture immediately, or subsequently at the point of location of the embolus or infarct? If so, why does not the vessel rupture when ligature is applied? Cannot thrombus, embolus or infarct occur without apoplexy? If infarct causes apoplexy by de-

stroying cortical tissue, why do not cysts of various kinds, infected or non-infected, or the loss of cortical tissue by trauma, produce it? Is not toxemia of the cortical area involved the cause of many cases of apoplexy? If so, what is the type of the lesion, and what are its limitations? Is apoplexy dependent upon the location of hemorrhage, thrombus, embolus or infarct? Do all such lesions produce some degree of apoplexy, regardless of location?

Is there any part of the brain substance which may be subjected to hemorrhage, thrombus, embolism or infarct without causing apoplexy or paralysis? Certain areas of the cortex may be removed or destroyed by abscess or disintegration without apoplexy or paralysis, unless the volume of tissue destroyed is exceeded by that which occupies its space. This increased volume may be due to fermentation of the resultant contents or the erosion of a vessel which pours out its contents to become mixed with pus or disintegrated brain substance and thereby suddenly increase the volume and consequent pressure upon cortical tissue. Why does not apoplexy always occur as the result of the removal of cortical tissue? If changes take place in the cortex supplied by a vessel distal to the occlusion or due to thrombus or embolism, why do not the same changes occur after ligation of a vessel? Is apoplexy due to pressure or the loss of cortical tissue? Is it not due to either one or both?

It is difficult to become reconciled to the belief that apoplexy is always due to the escape of blood alone from cerebral vessels into the cortex or ventricles, cavities or tissues surrounding the brain due to any cause.

Is it possible to have the condition known as apoplexy without pressure or paralysis? Is it possible to have apoplexy or paralysis without pressure? Why does not apoplexy or paralysis or both follow the loss of brain substance? Simple apoplexy is that form which causes death from coma, in which no cerebral lesion is found. May not this be ascribed to cerebral angio-spasm? It is known that spasmodic contraction of blood vessels occurs in other parts of the body.

The permanent effects of this form of anemia are dependent upon the length of time it exists. This will explain transient suspension of mental faculties, and, when prolonged, changes in the cortex which result from the absence of blood within or rupture of the smaller terminal vessels.

Spinal Cord.—The grosser lesions of this body have not been a lucrative field for surgery; however, there should be no cessation in the effort to develop it. The hopeless degrees of injury to the cervical vertebra are now in advance of remedial measures. This is especially so with the "broken neck." The remedy would seem to rest in causing the disorganized bony structures to become united by natural or artificial means. Just how this is to be accomplished has not yet been evolved, but it will probably be by direct artificial fixation with wire and artificial anchylosis of one or more vertebral joints by means of irritants, such as alcohol, carbolic acid, quercus extracts or galvano-puncture, because the loss of vertebral joint function seems necessary.

Thoracic Surgery.—Is rapidly undergoing evolutionary changes. This is shown in the successful work done upon the lung, bronchus, esophagus, diaphragm and thorax. Just what important bearing the pressure box will have upon advancing the success of this work remains to be determined. The broncho- and esophagoscope are innovations for diagnosis and treatment of foreign bodies. The injection of ether vapor mixed with air into the lung by means of a tube inserted into the trachea has been found sufficient to keep alive an animal a very considerable time, while the thoracic viscera is being manipulated for surgical purposes.

This means of sustaining life is the most practical of all yet devised for such a purpose. Meltzer and Auer have immortalized themselves with this if nothing more. The method will permit of surgical operations upon any thoracic viscera including the most difficult, the ductus thoracicus.

There is probably no chapter in surgery developed with more gratifying results than that of the *cardio-*

vascular system, but there remains one of its subdivisions—that of aneurism of the aorta and especially its arch—for the experimentor to develop. The half has not yet been said as to the possibilities of surgical accomplishment with disease and traumatic irregularities of the heart and its immediate branches. This branch of surgery is an assured entity now that it has been proven that the blood contained within the cardiac chambers may be diverted to a point beyond the aortic valves and that these valves and aortic lesions may be attacked surgically while the flow continues artificially.

The location of an arterio-venous anastomosis, congenital or acquired, may be determined by the presence of CO^2 in the blood. This is one of the most important diagnostic discoveries in this kind of work.

Cardiac Stimulation for Suspended Animation.—For an elaborate résumé of this subject, see Transaction (Surgical section) American Medical Association, 1906, pp. 504-535. This subject was initiated by Schipp, 1874, who compressed the heart with his fingers rhythmically, and Ricketts, B. M., 1877, who immersed the severed heart of a tortoise in warm water. Since then, medicaments and electricity have been applied in many ways, directly and indirectly to the heart for this purpose. Mammalian hearts have been made to contract under the influence of Faradism, after they have been preserved in salt and ice out of the body for thirty hours, thus showing the great vitality which they possess.

Adrenalin injected into the vessels arising directly from the heart has been the most satisfactory of all the medicaments. Crile has caused the heart to renew its contractions by this method two hours and forty minutes after it has ceased to beat. In this instance contractions did not continue for many minutes.

Digital manipulation by both direct and indirect methods have proven very effectual in a number of cases where the heart had ceased to beat. The greatest length of time it ceased to beat and was then made to regain and continue to beat by digital manipulation was twenty-one minutes. All necessary means for

resuscitation should be provided in every hospital and they should be resorted to in all cases of suspended animation, especially due to narcosis and injury. It is an act of more wisdom to apply them, though but one in fifty be saved.

Transplanting organs and extremities from one body to another with retention of function in both animal and man has been so satisfactory that it is only a question of a short time until its practical benefits are realized.

Osteo-ponthesis.—Is a possibility in the preservation of function of the extremities when osteo-regeneration is an impossibility. The reparation of osseous structures by transplantation from the lower animals, especially man's nearest allies, will be confined to the remoter districts because the large hospitals can supply daily almost any human osseous structure necessary for the purpose from the living or recently dead.

Implantation—Of bone for functional and cosmetic purposes is rapidly gaining favor. Extremities may be preserved by substituting the ulna or fibula for a radius humerus, tibia or femur, and the nasal prominence, especially, by grafting pieces of bone from the spine of the tibia.

Fractures.—Direct fixation, especially for fractures of the femur, humerus and inferior maxillary bones, is now the most rational means of securing perfect apposition. Thin concave steel plates secured with short wood screws, with the thread cut to their heads, as suggested by Lane, are most perfect.

This method should be generally adopted and he who is not capable or disinclined to do it should seek those who can and will do it.

It was our privilege to discuss this question favorably in the *Times-Register,* vol. xxviii, 1894.

Cosmetic Surgery.—Defects such as found in the ears, eyelids, lips, nose and other parts of the head, face and neck might be considered in its zenith, but there remains much more to be accomplished, especially with the ear, which has so long defied correction. It is believed that this particular question will be solved by utilizing an osteo-periosteal flap from imme-

diately behind the ear, having its base upon the anterior border of the mastoid process, while the various questions pertaining to the eyelids, lips and nose will be solved by the use of single and double pedunculated and those not pedunculated. In other instances they will be made to conform to other features without the addition or subtraction of parts.

Abdominal Surgery—Has startled the scientific world until even the laity has come to believe that there are now no impossibilities within its domain.

The achievements in surgery of the abdominal aorta and ascending vena cava are indeed few, but enough has been accomplished to warrant the statement that aneurysm and wounds of these vessels will soon be successfully treated by suture. It is the last of the abdominal viscera to be attacked surgically.

Alimentary Tract.—It would be useless to mention in detail the achievements in this department of surgery, because of the perfection of the great number of methods devised to overcome the various forms of irregularities to which it is subjected. However, the temporary or permanent elimination of the sigmoid for disease, especially of a malignant character, should be more often considered.

But there remains much to be accomplished in the newer work and much of that of the past to be relegated. The belated ovary should be more thoroughly and generally considered, now that normal menopause can be assured after implanting ovarian tissue extraperitoneally.

Intra-peritoneal exploratory hysterotomy—Offers much for both diagnostic and curative measures. Conservation of the uterine tissue is necessary, because its secretion has no doubt some beneficial influence upon the general system.

Malignant and certain forms of non-malignant neoplasms require its total extirpation, but otherwise it should be done with the greatest caution.

Mammary nipple—Should be preserved for cosmetic purposes when the gland is removed for non-malignant, and malignant neoplasms when it is certainly not diseased. This is best accomplished with a

lateral semi-circular incision of the cutaneous structures. The censure that has been experienced for removing the nipple together with the gland in one case in which the neoplasm has not recurred during fifteen years, has been the basis of this conclusion. The rule, therefore, has been since then to preserve the nipple, and in no case has there been reason to regret it, though many times recurrence has ensued, but not in the nipple.

Nerves—When injured are not now neglected as they have been. Severed nerves are anastomosed, many times with almost perfect restoration of function, while the dire results of recurrent laryngeal, musculo-spiral and other paralyses are often completely overcome by implantation. The function of the great sciatic nerve has been partially or completely restored after anastomosis by suture in nearly all of the fourteen cases completely severed in a few instances for more than one year.

Bismuth paste will be the means of dispensing with much surgery. It is not only a curative measure, but pain, disfigurement, loss of time and the dangers of any anesthetic (local or general) are avoided, because they are not necessary. This paste should be employed in all fistulous tracts before surgical measures are resorted to, and in many abscess cavities after their contents have been evacuated, especially those in and about the rectal and perineal regions. Great care should be exercised in selecting bismuth that is entirely free from arsenic, several fatal cases having been due to such poison. Such a preparation can now be had, but even that will produce symptoms of poison identical with those of lead, even to wrist drop, if used in large quantities, such as has been done in the pleural cavities. It is not necessary to use large quantities in any cavity, because very small amounts will answer every purpose. There is considerable doubt about the propriety of preserving bismuth paste in lead, tin or other metallic tubes, because of additional dangers of poison.

What are the most important influences bearing upon the further development of surgery?

The future holds in store undiscovered more definite means of deciding the question of the necessity for surgical interference. These latent advantages added to those already known will have a great bearing upon surgery. The means for the dissemination of this, together with all other surgical knowledge, will add more to its perfection.

Vivisection in both animal and man is essential for a more rapid progress in the science of medicine and surgery, and, unless it receives the support of legislation in matters pertaining to it, the benefits to be derived must be denied all forms of life; for animals benefit, alike with man in all such discoveries, as is demonstrated by the work of the veterinarian.

That more perfect knowledge of them may be had, criminals should be given an opportunity to accept or reject the right to subject themselves to the hands of the experimentor, even though their lives might be jeopardized. Their reward should be their liberty. They are many times promised this for services of less importance. Laymen enact laws to standardize the practice of an art and then endeavor to check the ways and means of obtaining and advancing it. It cannot be said that such opposition is confined to the ignorant alone, for many of scientific attainment have been enthusiastic in condemning it. Capital punishment should be abolished, for life should not be taken except in self-defense. The evolution of punishment for crime is fast approaching the elimination of punishment by death, because emasculation together with disfranchisement and labor will ere long obtain. Whatever value the criminal possesses should be utilized to the best advantage. Its destruction is a crime that should not and will not long be sanctioned.

Diagnosis is a most important adjunct, because without knowledge of a condition a remedy cannot be applied. The X-ray, especially in surgery, has become a necessary aid for diagnostic purposes. As a therapeutic agent it does not have so wide a scope. However, its influence is well established in Hodgkin's disease and various other malignant neoplasms. Concerning many epitheliomata, there is some question about its

advantages being superior to arsenical paste, alone or combined with excision. With its many lurking dangers, there is no cessation in research with the ray. The scholarly work of Kassabian and his confrères who have had a similar fate, is only the beginning of a new era in surgery, and it will stand as a lasting monument to their energy and fearless and noble sacrifice.

Serum and extracts have been so perfected that they may be employed as adjuncts to surgery, especially in the treatment of exophthalmic goitre and malignant neoplasms, even though their effects alone may not be curative.

When it was recently discovered that an aqueous extract of a part or all of one testicle, injected into the animal from which it was taken, will cause the other testicle to become sterile, the true application of the principle was not evolved at once, but it was soon applied to sarcomata with most gratifying results.

But an interesting question now arises concerning the influence of testicular extract. What will be the effect of extract made from a testicle removed from one in whom no spermatozoa are present? Will such an extract sterilize one who possesses spermatozoa? Will sarcomatous extract prove to be prophylactic, if it be true that it will cure sarcoma, and will a sarcomatous extract made from one indiv'dual cure sarcoma in another?

The homeopathic law is amply verified in sero-therapy, though a chemical instead of a biological application was its foundation. Jenner reported his discovery of vaccinia in 1798, after thirty years of study. The law was not announced until 1789, while Hahnemann was studying "Cullen's Materia Medica," he having abandoned physics for chemistry. His first publication did not appear until 1805, and the last in 1821. It would therefore appear from circumstantial evidence that the discovery of this law was prompted, or at least somewhat influenced, by the prevailing knowledge of the influence of cowpox upon smallpox, especially during the thirty years 1768-1798. However, the honor of proclaiming the law should be given to its originator. Hippocrates knew of the law, "like cures

like," but little attention was given to it. This law is also recognized in the effects of the X-ray, as it will cause and cure malignancy, but will not cure that which it produces, though macroscopically and microscopically they are similar. Tetanus, diphtheria and meningitis share with smallpox and cancer the benefits of this law, while other diseases no doubt will do so.

Etiology of Malignant Growths.—Remaining undiscovered, would it not be well to predicate its investigation upon such growth in vegetable life? Cellular growth of trees becomes disorganized in a similar way to that of animals, sometimes with the same results—the loss of a member, destruction of the body, or eliminated by spontaneous or artificial methods, depending upon location in the body structure, arrangement of the cells in that particular location, or both. Possibly some parasite or bacteria may have been the cause, alone or in combination with these.

Pituratine is one of the more recently discovered extracts—surely the most powerful, for it is seven times stronger than adrenaline as a cardiac stimulant. It acts especially upon the uterine fibers, causing them to become almost immediately contracted. It is probably a very useful but a most dangerous remedy, not to be generally employed until after further experimental research. It may be found to be a remedy of choice when contraction of the uterine fibers is indicated. Like adrenalin, it may prove to be a most important adjunct in the treatment of shock, which should at all times be avoided.

Shock.—Every precaution should be taken to prevent, and every known remedy employed to combat it. Shock is probably greater with than without anesthesia with loss of mental consciousness. Any method that can lessen or eliminate it will receive exalted commendation.

Ambulancing patients with acute surgical conditions should, if possible, be avoided. The advantages of an operating-room and its associated hospital conveniences causes the welfare of the patient to be overlooked in many instances. The advantages of the hospital operating-room can be canceled in parallel lines with

those of the home or place of accident in much emergency surgery, in favor of the latter. Too many die en route or soon after arriving at the hospital, with or without an operation.

Anesthesia, both with and without loss of mental consciousness, must be better understood. The induction of the loss of mental consciousness is rapidly being supplanted by general and local anesthesia without it, because mortality and after-consequences are less. Anesthesia by inhalation and spinal injection are the most dangerous of its many forms, especially spinal. It has been proved that degeneration of the cord results from the trauma produced by the insertion of the needle and the inflow of the anesthetic solution into the cord.

Asepsis, not antiseptics, is to be recognized as the safeguard to infection. It will be more generally and perfectly practiced as its importance is more fully realized.

Early operation is to be considered in almost all surgical operations. This fact is well established, and will become more generally recognized with added experience. In general, the omissions in surgery are greater in number than those of commission.

Prophylactic surgery will become more generally accepted, just as prophylactic medicine has become recognized. This has already taken its origin in the appendix, for this question has been agitated with some little favorable comment. If sanitary measures can be employed to prevent a medical disease, why should not surgical measures be inaugurated to prevent a disease that is known to be surgical? Would this not be logical with tissues that have no apparent function, such as tonsillar and appendicular structures? Of the two, the latter is the most dangerous when pathologic, but less so to remove when non-pathologic. The surgeon who fails to remove either a normal or a pathologic appendix when the abdomen is opened for any cause, fails to do his duty. This may also be said of the tonsil. Normal prophylactic appendicotomy was advocated by me in the *St. Louis Medical Review,* vol. xii, 1900.

Rapid operation is of great importance in all surgical work. It must not be done at the sacrifice of thoroughness, but it should be done. Those blessed with dextrous simplicity are greatly in the minority, but they have many advantages. There are many features of technique that would be better dispensed with when the results will be superior without them.

Cosmetics are expensive and unnecessary luxuries when they are applied to a living creature while in a state of mental unconsciousness due to artificial means, especially with added surgical shock, so that dexterity is as essential as the knowledge with which it is associated.

Specialism will always take rank, but the surgeon who can meet the greatest number of emergencies, and meet them well, will have precedence. The general surgeon is supposed to do this, and he must do it because of the many complications and coincidences that often arise. They are too numerous and well known to enumerate. It is seldom practicable to have as many operators present as the number of different kinds of operations sometimes necessary to be done at one sitting.

The limitations of any specialty cannot be defined. The confusion arising from attempting to do so has often been disastrous. That the border-line has not been defined between the surgeon and the internist is too frequently demonstrated in diseases of the abdominal viscera. Some of these questions have been settled, though surgeons many times disagree among themselves.

Technique rests with the individual. A few inherit it, some acquire it, while others possess it both by heredity and acquisition. None can perfect it, though it may be improved by experience and observation, especially with the aid of the experimental laboratory, which every institution of surgical teaching should possess. Such a course should be compulsory, and a higher standard of work required from all, especially those who contemplate specializing in the science of surgery. It is appalling to observe the prevalence of the absence of these accomplishments. It is as essen-

tial to be dextrous in the use of instruments as it is to know for what purposes they are constructed—whether they be for surgical, astronomical or other purposes. With the absence of the opportunity to obtain such requirements during the college course, they may be acquired by diligent research independent of it. Many great surgeons have gained such dexterity in this manner, so that those who have not the advantages of an experimental laboratory need not be discouraged. Mueller, the great zoölogist, when asked why he continued to work, replied: *"Die Blut klebt auf der Arbeit"* (blood clings to the work), *i.e.*, it is in the blood.

Pre-operative care has become recognized as having an important influence upon the immediate results of surgical trauma, and he who fails to give it due consideration fails to do his duty. All physiological questions should, if possible, be settled, and environment made favorable.

Post-operative care is rapidly gaining favor, for it is often as important as the operation for which it is required. The caretaker should assume its responsibility with the operation and necessary dressings and devices. It is a position worthy of the highest skill and the reward most commendable.

The relation of surgery to medicine always has been, is now and always will be intimate, because of the defective diagnostic measures, but there is no reason why one should be sacrificed for the other. That they can never be separated is demonstrated by the fact that preventive and curative measures are essential in much surgery. That a surgeon versed in the art of medicine becomes more skillful is evidenced in many ways. That the internist who is familiar with surgical pathology inclines more to surgery, goes without saying. Sentiment should not influence a diagnostic question or surgical operation, for there is no sentiment in science. "So have I heard Achilles' and his father's javelin caused pain first and then the boon of health restored."

From THE LANCET-CLINIC, November 26, 1910.

THORACIC SURGERY.*

BY BENJAMIN MERRILL RICKETTS, M.D., PH.B., LL.D.,
CINCINNATI.

To be with you is a distinction that is fully appreciated, and it is hoped that the spirit of aggression will dominate every honest effort to have this become one of the most progressive and well-equipped institutions of medical teaching. The sentiment that prompts this effort is one of ambition, and he who is without it had best return to his former habitat.

The subject that this introduction represents is one of the newly developed fields in surgery, and while it may not be popular with all, its importance cannot but be fully realized. It is, therefore, presented for your most sincere consideration, with the hope that the effort necessary to do so will not be forgotten. The amount of enthusiasm necessary to make the subject interesting cannot be limited to those who enter the arena of science, and it is well that it be understood that there must be harmony and co-operation in any and all efforts to become familiar with it. There will probably be slight digression from this subject during the year, but it will concern it in some way.

To better understand what can be done, it is essential to know how and what has been done. With this in view, a sketch of the subject in general will be presented for your consideration. Following this the various chapters of the subject will be given, so far as possible, in the order of their development.

In no department of surgery is the daring, skill and

* The first of a series of lectures on the thorax and its viscera, delivered at the American Medical College, September 13, 1910.

versatility of the surgeon and his attendants better demonstrated than in this department. For this reason it is believed that the most malignant growths will ere long be deprived of their deadly character and cease to hold high carnival in the living body.

Surgery of the thorax concerns all forms of disease and trauma acquired or induced upon that part of the body bounded above by the soft structures of the neck and below by the diaphragm and lower margins of the ribs. This will necessitate the consideration of the soft and hard structures (including the cord and vertebræ) and all viscera which it contains.

That the subject may receive proper recognition, it will be necessary to consider each separately, giving etiology, symptoms, diagnosis, method of operation and after-care.

No definite period can be assigned when attention was first directed to this department of surgery, but it is much earlier than any recorded evidence would indicate, probably before anatomy was considered in any way whatever.

There are probably none of the conditions to be mentioned that have not existed since the creation of animal life, whatever difference there may be in the ways and means of their production. The teeth and claws of wild animals, stone missile and spears of various kinds, were the methods of inflicting wounds upon earlier animals and man, and as the character of the weapon has become changed, that of wounds and their pathology is different.

Injuries to the soft structures overlying the bony thorax were given first consideration, but with keener observation the involvement of the harder structures was detected and treated in some advanced manner. Degrees of injury became better classified, and their appropriate care adopted, until injuries of the pleura and viscera were to be recognized so perfectly that surgical measures for their relief became more skillfully employed.

The Bureau of American Ethnology is rich with the history and description of illustrated prehistoric weapons. Occasionally a well-preserved bony skeleton of

both animal and man is found with one of these weapons embedded within it. Such human specimens have recently been found among the remains of the mound-builders at Madisonville, O., and in a cave in Breathitt County, Ky.

Experimentation upon the chest and its contents, like such work upon other tissues and organs of the body, has been the greatest factor in placing surgery of this upon the same basis with that of any other part of the body. While much of it has not been verified, all has been necessary to complete a chain of evidence to show what has been accomplished, and he who would decry it might be placed in the same category with that in which S. S. Prentiss placed the man who would not help Ireland during the famine of 1849, when he said: "He who would not aid such a cause is not a man; he is not worthy the name of man; he should be returned to nature's mint and re-issued as a counterfeit on nature's baser metal."

Anatomy of the chest was little known until the fourteenth century, when it became the fundamental study to surgery, though it is believed that those more ancient were particularly versed in it. There can be no doubt that the anatomy of the chest was as thoroughly understood during the succeeding centuries as that of any other part of the body, though the physics of respiration were not known.

The chest has been compared to a box containing a vacuum in which there is placed a rubber bag, which, when filled with air, can be expanded and contracted with ease. This is true in a measure, but with one there is a vital element, while with the other there is not.

The thorax, originating from a single cell, becomes more complex until its final development, which really is not complete until adult life, though it functionates from the first inspiration of air. Embryologically, it is first observed about the tenth day, and continues to be prominent during fetal development.

The ribs, cartilages and vertebrae constitute its hard structure throughout life, but they become less elastic with advanced age. The periosteum and pleura serve

to make the thoracic cavity a closed one, while within this cavity are to be found the lungs, pleura, trachea and bronchi, heart, pericardium, aorta and its immediate branches, diaphragm, ascending superior vena cava, esophagus and ductus thoracicus, each of which is subject to disease and injury.

It was not until during the first half of the nineteenth century that the law of pneumatics was recognized as the one which dominates respiration. The injection of ether vapor mixed with air into the lung, maintaining life for several hours, reflects a shadow of doubt on this law, because expansion and contraction of the lung are not necessary for pulmonary function. However, the importance of atmospheric pressure has not been altogether forgotten.

Exploratory incisions, for the purpose of determining the degree of disease or injury to the hard structures of the chest, especially the vertebræ, have not been given the credit they should have; neither have diagnostic measures been properly employed with injury or disease of the soft structures and viscera. This is due to want of experience and aggression, the essentials to surgical progress. They will take their origin in the larger surgical centers, as a rule, because of the great amount of material and opportunity to utilize them under the most favorable environment. Fortunately, however, much has already been done under unfavorable circumstances to prove what may be expected.

One by one the deadly effects of opening the serous cavities have been made to yield to the skill of the surgeon, until now they are opened with impunity.

The following historical review, though necessarily more or less imperfect, will serve to illustrate the rapid progress in the care of surgical injuries and diseases of the various tissues and organs entering into the structure of the thorax.

It cannot be said, judging from the present-day teaching, that Rolandus, who amputated a lobe of the lung protruding through the intercostal space, did it under aseptic environment, but he removed it as early as 1499 A.D., and the patient made an uninterrupted

recovery. He was succeeded by Tulpius, 1764, who ligated and cut away three ounces of lung tissue, resulting in complete recovery. It was Ramsey who, in 1668, gave one of the first descriptions of parasites and their results upon the lung.

Much has been said since Buchetfield's interesting paper (1671) on foreign bodies and their results in the lung, but it is to be regretted that their various interesting phases cannot be considered at this time. Bligny (1670) advocated incision for abscess of the lung, and Purman (1692) recommended it for hemothorax, chest wounds, cavities of the lung, etc., so that the wisdom of their teaching cannot but be appreciated.

Bronchus.—Until recently, surgery of the trachea and bronchus was limited to tracheotomy, which gave access to both the trachea and bronchus, especially when dealing with foreign bodies, membranous and other forms of obstruction. Within the last five years the first removal of a foreign body from the bronchus by direct thoraco-pneumono-bronchotomy was successfully done, for a collar button, at Erie, Pa., and reported in the *Annals of Surgery*.

Concerning gunshot wounds, Mallet (1743) published a report of a ball having passed through the lung, and Rigby (1790) another, resulting in recovery. However, the most destructive guns, such as cannon, had been employed by Amurath II at the siege of Constantinople, in 1422. There was, no doubt, earlier recorded evidence of wounds of the chest due to missiles projected by explosive weapons of smaller caliber. There are now innumerable missiles, varying in size, shape, weight, kind and consistency, velocity, number of revolutions and character of explosive, while the clothing through which the missile must pass varies in kinds of material. In all of these there is a greater element of safety from infection than with those of ancient times. The most prominent of these is increased velocity, which produces a greater degree of heat in the missile, causing it to become sterile and render so any fabric with which it comes in contact.

The character of weapons that produce lacerated and incised wounds has become changed, as is demonstrated with sabre and bayonets, which are now smaller. The knife-blade continues to be the most common means of inflicting incised, and machinery, lacerated wounds, the latter being in greater proportion than formerly.

Abnormalities of the lungs may be congenital or acquired. It was Tichomiroff (1783) who reported very concisely a case of congenital absence of the left lung found in a woman twenty-four years old, who died of pneumonia. An injury of the left thorax would not therefore be as serious as it would have been with the presence of the left lung. These abnormalities are not confined to the lung alone, for there is not an organ or a structure of the thorax that is not subject to the law governing congenital defects. Correction by surgical measures may become necessary with one or all at any time during life.

Pathology of the thorax and its viscera has now become thoroughly considered so far as present-day teaching is concerned, but, like pathology in general, it must undergo many more evolutionary changes before it can remain at rest. Three teachings of pathology within a century would indicate that, as is shown in cancer, syphilis and gangrene.

There is perhaps no parasite existing in the lung of both animal and man that has not existed for many generations, all no doubt being governed by the laws of evolution, but, like fungi, atelectasis and pneumonotosis, was not observed until within recent years.

Rupture of the lung was also overlooked, if the absence of literature is to be considered evidence, until Tait (1844) wrote his paper upon the subject. Since then many reports have appeared, illustrating the various types of rupture and conditions under which they occur.

The esophagus has for twenty years been attacked surgically, usually for stricture in the upper portion, but Willy Meyer has recently demonstrated by means of the pressure box that its lower third in animals may be anastomosed with the stomach through the pleural cavity by lifting the cardiac end of the stom-

ach upward. Thus it is proven that at least the upper and lower thirds of the esophagus can be dealt with successfully by surgical measures. This will be the means of not only prolonging but saving many lives that have for the want of such knowledge been unnecessarily sacrificed.

The diaphragm is the chief characteristic in mammals, especially man, but subject to many anomalies, even to its entire absence, injuries and diseases. Deliberate surgery, such as direct suture for incision, dates from De Nicola (1891), who sutured a rent in the diaphragm. Since then many have reported similar experiences, among them John Young Brown, who has done a considerable amount of suture for such injuries in this city. Penetrating wounds of the abdomino-thoracic region now demand exploration, while formerly they were left to nature and "good luck." Speculation in such injuries is no more to be tolerated in this than in that of any other region.

Ductus thoracicus surgically remains in its experimental period, though much has been done to offer encouragement. The discovery of methods that will place this duct upon the same surgical footing as that of the bronchus and esophagus would add much to close the chapter on surgical impossibilities. It is a glowing tribute to experimental surgery to have decided this question, and it may soon be verified in man, the rule being that "the end justifies the means."

Spinal vertebrae are referred to, as they pertain to, the thorax, because it is upon the twelve dorsal vertebræ that the thorax is constructed, and while they are the seat of injury and disease, there are many which are not confined to it. Only within recent years has anything surgical been directly applied for their relief. However valuable exploration may be, it has been infrequent, because injury of these vertebræ, when associated with the ribs or pleural cavity, is most frequently the result of explosive missiles, which have offered so little hope. There is now no plausible reason why any of the vertebræ, especially those in the dorsal region, should not be attacked, if necessary with complete removal, without the loss of life.

Spinal cord injuries concern more or less the thorax and pleural cavity, especially when the continuity of its overlying bony structures is disturbed, so that it is often necessary to give it secondary consideration. Unless there is disorganization of its cellular structure, it may be exposed and relieved of pressure without being necessarily fatal.

The history of injuries to the heart and blood-vessels is equally ancient with that of the lungs, but without any attempt whatever to correct or remedy them until a much later period. So much has been accomplished in overcoming injury to the circulatory system that its diseases are now receiving surgical consideration, in a few instances most favorably.

Gunshot, lacerated and incised wounds of the heart date from the time of Paré (1552), who stated that such wounds must result in instant death. Various theories were offered in explanation of how death occurred from such wounds, among them, profuse bleeding (Lenac, 1749) and obstruction of circulation depending upon distension of the pericardium from bleeding (Morgagni, 1765). These explanations stand to-day as the most plausible causes of death resulting from such injuries, though infection should be added. In no department of surgery have its revelations been more startling than in gunshot and incised wounds of the heart, because the heart has always been considered the most vital organ in the body.

Cardiomorphia.— Occasionally imperfect fetal development will cause the heart to have but two or three cavities. Sometimes five and sometimes six cavities are present, and life is maintained indefinitely after maturity.

Such irregularities are observed in transposition and sometimes obliteration of the pulmonary vessels. The foramen ovale often continues patent because of the want of a secondary septum. These defects were observed and communicated by Stenon (1673), Amynd (1732) and many others who have since made contributions indicating the frequency with which they occur. However, hearts of various kinds of animals vary materially in their anatomical construction. For example,

the aorta of the crocodile arises from the lower part of the right ventricle. The most perfectly constructed heart is that which separates the arterial from venous blood, and the imperfect heart is that through which passes the two combined.

Bartholinus (1678) was among the first to show the various types of the cardiac system, though Cesalpino (1569) was the first to use the term "circulation of the blood." Servetus (1553) and Vesalius (1555) had established the true doctrine, and had exploded that of Cesalpino, but it remained for Columbo (1559) to suggest the pulmonary course of the blood. There is no disposition to reflect upon the work of Harvey by referring to these facts, but as there is frequently a disposition not to reveal all the facts, especially when referring to discoveries, it is well to keep alive certain of them. He died in 1657, with all the honors of having discovered the true circulation of the blood.

Harvey was considered a madman by many of his contemporaries, and lost much of his practice as the result of his proclaiming his discovery of the circulation of the blood. He was born at Folkstone, 1578 (twenty-three years after the works of Servetus and Vesalius), and was supposed to have first promulgated his discovery of the circulation in his Lumley lecture, 1615. His dried dissections of arteries were carried by Edward Home to the Royal College of Physicians at London about 1815, and presented by the Earl of Winchelsea, and, like the bone which Fitzclarence secured from an Egyptian sarcophagus and presented to His Majesty as the thigh-bone of the king of Egypt, was respectfully preserved in the College of Surgeons —but was proven to be the thigh-bone of a cow. These arteries may have been taken from some other animal than man, so unrecognizable are they.

Harvey, replying to Bayle's query as to what were the things which induced him to think of the circulation of the blood, said: "When I took notice that the valves in the veins of so many parts of the body were so placed that they gave free passage to the blood towards the heart, but opposed the passage of the blood the contrary way, I was invited to think that so prov-

ident a cause as Nature had not placed so many valves without design; and no design seemed more probable than that since the blood could not well, because of the interpassing valves, be sent through the arteries and return through the veins, those valves did not oppose its course that way."

Cesalpinus, in his "Questiones Peripateticorum," lib. v., June 1, 1559, says: "Thus the lung, drawing the fervid blood from the right ventricle of the heart, through a vein similar to the arteries, and returning it by anastomosis to the venal artery, which extends to the left ventricle of the heart — cold air being transmitted, meanwhile, through the passages of the aspira arteria (or breathing arteries), which are in juxtaposition with the venal artery, not, however, communicating with the openings in the manner supposed by Galen—tempers (it) by a single touch. This circulation of the blood, from the right ventricle of the heart through the lungs into the left ventricle of the same, is best proven by dissection; for it is certain that there are two vessels ending in the right ventricle and also two in the left. One of these receives only, the other distributes the membranes by this ingenious arrangement."—*Colton's Lacon.*

Cardioclasia, rupture of the heart, was observed by Henroz (1758) and Mummsen (1764). It is hardly probable that all ruptures result fatally when it is known that clots will permanently occlude the smaller rents, but if such lesions could be discovered at the time of their occurrence, immediate suture would result many times favorably. The most important question now arising is early diagnosis of the lesion, for, this once determined, the remedy is known and may be applied with a reasonable degree of safety.

Ectocardia.—Abnormal position of the heart is not an infrequent occurrence. It may be congenital or acquired, may occupy any part of the thoracic or upper abdominal cavity, or be exposed through the thoracic wall, without causing death unless the degree of ectopia is exaggerated. Abernethy (1793) reported extensive transposition of the heart and blood-vessels with singular function of the liver. Acquired ectocardia may

be corrected in many instances, but for the congenital form there is nothing to be done.

Cardioliths and foreign bodies were found in the heart by Goodwin (1700), who reported a case of polyform concretions and so-called "stones" in another. These are the result of calcification, and may attain sizes of considerable proportions. Foreign bodies have been known to enter the chambers of the heart and remain there indefinitely. Wood (1814) reported such a case, and White (1853) one where a bullet had remained in the cardiac wall for twenty years. Balch (1882) also records one having remained there for eighteen years. Needles and pins have quite frequently been found in the walls and chambers of the heart, several of the latter having been removed from its wall without causing death.

Cardiotomy and cardiorrhaphy are the result of all former observations and work upon the heart, and they represent the most modern surgery. Cardiotomy may be the infliction of a cutting wound of the heart by accident or deliberation. Aprillis, in 1680, reported in the first medical journal ever published, Obs. x, a sword wound of the right auricle, though suture was not applied to such wounds until 1893, when Williams, a negro physician of Chicago, did it. The mortality for the 170 such operations since then is about 60 per cent. Several such lesions have been treated successfully with suture by Nietert and Rassieur, of this city. This mortality will be lessened by more aggressive and technical methods.

Pathology.— Non-malignant growths of the heart were recognized as early as 1680, when Pretten discovered polyps within its chambers. Since then, many other types have been found invading the myocardium. Gangrene, syphilis and various forms of sarcomata and carcinomata have been more recently added to this list.

Parasites, fungi and bacilli of the heart date from 1718, when Kortholt contributed to the subject of animal parasites within the heart.

Experimental research on the heart began with Legallois, in 1813, who attempted to discover the principle of life, especially of the motion of the heart. My

own work began during 1876-77. Since that time many contributions have been presented, bearing both upon its physiological and surgical aspects, so all that has been accomplished has not only developed from experimentation upon lower animals, but with it.

Vesalius is accredited with having been the first to open the breast of a living human being (1564). A Spanish gentleman under his care appeared dead, after having requested to be opened. While Vesalius was doing so, signs of life appeared while the breast was open. The heart began to beat, and continued to do so for several minutes. Friends of the dead patient prosecuted Vesalius for murder, but the King of Spain had him acquitted, providing that he expiate the crime by going to the Holy land, which he did, but he lost his life in a storm while returning. This incident was the occasion of the following notice, posted by the Barbers' Company, July 13, 1583: "It is agreed that if any body, who shall at any time hereafter happen to be brought to our house for the intent to be wrought upon by the anatomists of our companies, shall revive or come to him again, as of late has been seen, the charges about the same body so reviving shall be borne, levied and sustained by such person or persons who shall happen to bring the body; and further, shall abide such order or fine as this house shall award."

Aneurism of the heart was written about by Craig, in 1843, who mentioned false consecutive aneurism of the heart. Since then much has been said concerning the various forms of cardiac aneurism.

Aneurism of the aorta and its immediate branches is one of the last to come within the domain of direct surgical measures. However, the ligature has been employed on its branches for that purpose for almost a century, and the injection of wire into aortic aneurisms for the last twenty-five years, each done extra-thoracically. Now that the thorax may be kept open for at least several hours with the retention of respiratory function, direct surgical measures may be employed with comparative safety.

Thus it is apparent, after reviewing the surgical history of the thorax and its viscera, that its foundation

was not constructed in a day, but that each fact has been preserved in an honest endeavor, until a structure will ere long be completed to represent the untiring energy, skill and unselfishness of those who have lived uncrowned, died without comfort, and whose ashes are mingled with unknown dust.

It now becomes necessary to view the subject from an entirely different position—that of present-day surgery and what is expected to result from it, so far as the future is concerned. Our flight of the imagination, so far as to what may be done, may be well taken so long as there is life, for surprises will overtake us from time to time and our efforts may be rewarded a thousand-fold.

Asepsis should be the prevailing thought and ambition of every one who has to do with wounds, in this as in other parts of the body. It is just as essential in the care during the intervals and applying the subsequent dressings as at first. It is therefore necessary to make sterile all bedding, instruments, dressings and utensils that are to be used in the care of the wound, also to take every precaution to guard against infection through the medium of visitation of those other than regular attendants. Infectious and contagious diseases should receive especial attention, if their presence is suspected or recognized in members of the families of those who visit the home. Only under urgent circumstances should the attending physician have anything whatever to do with the wound or its dressings, if he is caring for patients who are afflicted with contagious or infectious diseases. He should delegate others who are free from such infection to do so. There is absolutely no way by which the human body can be made aseptic. If, in cases of great emergency, it becomes the duty of the attending physician to have to do with the dressing of the wound, he should use sterilized rubber gloves absolutely free from perforation. This is the best that can be done under the circumstances. The use of such gloves is a better guard against infection when the physician has the cases of infectious or contagious disease, and they should be used whenever possible for this purpose. Surgical

cleanliness is the greatest safeguard, and should ever be uppermost in the minds of those who are to assume the responsibility of the after-care.

Drainage, when properly secured in surgical or traumatic wounds, is of veritable value. It prevents the accumulation of pathologic secretions and secretions that may become pathologic. Secretions, if not pathologic, become harmful mechanically if not absorbed more rapidly than they are produced. When pathologic, they should not be permitted to become mixed with other infections. If sterile, still greater precautions should be taken to prevent them from becoming infected at all. This is best accomplished by thorough cleanliness and proper material used. Tape, wick and gauze are most efficient, but rubber tubing is preferable if the fluid is thick and profuse, with a disposition of the wound to become closed. Drainage may be continuous or interrupted, temporary or permanent. Continuous drainage is better accomplished by gravity when the fluid is thick and profuse. It is fairly well accomplished by capillary action through gauze or tape when the fluid is thin or small in amount. With either of these conditions it is essential and necessary to continue drainage as long as fluid is secreted. Then, and not before, should any means of drainage be dispensed with.

Irrigation is seldom indicated in infected, traumatic or surgical injuries of the chest or its viscera; never in non-infected wounds. The course and return of the fluid are uncertain, and its effects more harmful than beneficial. Sometimes its mechanical effects are detrimental, especially antiseptic medicated solutions and peroxide of hydrogen, because of both their mechanical and poisonous effects. Indications for irrigation are such as not to be mistaken. They are such as large open wounds, with adhesions sufficient to prevent fluid entering the thoracic cavity; when the general wound is not connected with other cavities; where there can be no question as to the return flow, and where the amount of secretion is considerable. The frequency demanded by these conditions varies, but usually should be every eight hours, oftener if necessary. Sterilized

water alone should be used, heated to the degree of tolerance and the amount necessary to make the granulating surface clean. The elevation of the tank should not exceed four feet.

Sutures date from Susrutus, who applied a ligature to the umbilical cord as early as 1500 B.C., though Paré has been given the credit for being the first to use ligatures for occluding severed arteries. They, together with sutures, have been an important element in all kinds of surgery, but with none has their value been better demonstrated than in thoracic surgery.

Sutures and ligatures are of great importance in the after-care, depending upon the purpose for which they are used, whether temporary or permanent, absorbable or non-absorbable, vegetable or animal tissue, sterilized or non-sterile; their color or compactness; whether they are in mucous, cutaneous, adipose, fascial, tendinous, muscular, periosteal, bony, vascular, glandular or nervous tissue; whether they become infected or not, or whether one or more or all are to be removed before they have served their purpose; also the character of the blood, for in some mysterious way absorbable sutures are disintegrated much earlier in certain bodies, especially during menstruation. Any of the materials enumerated may be used for temporary purposes in any of the tissues designated, usually that which is absorbable for permanent and non-absorbable for temporary.

In the presence of infection with either, it sometimes becomes necessary to remove one or all before they have served their purpose. Fortunately, blood-vessels to which they have been applied seldom require reapplication of ligatures, because it does not become necessary to remove primary ligatures in infected wounds until they have remained several days.

With non-infected wounds, the removal of sutures does not become necessary until they have fully served their purpose. Usually every other, beginning with the proximal one, may be removed on the fifth or sixth day, and those remaining on the seventh or eighth day. The sub-cuticular linear suture, with protruding ends, may be removed on the fourth or fifth day.

Dressings should be sterile gauze that will readily absorb secretions. The amount should be small, unless drainage has been provided for, then it should be made proportionate with the amount of secretion to be discharged within a given time. If the primary dressing is without drainage, and to remain intact for several days, adhesive strap may be utilized to advantage. If secretion is present, a soft towel (or similar material and shape) may be adjusted around the chest over the gauze with safety pins that may be easily readjusted whenever necessary. Voluminous dressings, with or without cotton are unnecessary, simple dressings that will permit the circulation of air being infinitely better. As a rule, aseptic dressings should be applied daily, after changing a primary dressing that has become saturated without provisionary drainage. The primary dressing may remain throughout convalescence unless one or more of the following conditions arises: (1) Hemorrhage, (2) soiled dressings, (3) temperature, (4) pain, (5) distension, (6) cardiac changes, (7) respiratory changes, (8) change in facial expression. Any one or more of these conditions may indicate the removal of the primary dressing at any time, and they should be done with reference to asepsis, comfort of the patient, and without disturbing the means of drainage, nor consuming any more time than is absolutely necessary.

Posture has much to do with giving comfort and shortening the time of convalescence. Recumbency, if prolonged, induces dizziness when the inclined or erect position is assumed, so that the change from that of the recline to incline, and incline to erect posture, should be as early and rapid as possible. It is usually necessary to insist upon such changes, often beginning upon the day of operation. Drainage is more easily and perfectly accomplished, in many cases, when the erect or semi-erect posture is assumed.

Transferring a patient from the operating-room to the bed which is hereafter to be occupied, is a responsible undertaking and one involving great danger to the patient and legal responsibility of those doing it. The number of attendants should be governed by the

exigencies of the case, more than two seldom being necessary, and they should be selected for their adaptability and cleanliness. The means of transferring patients are the stretcher, rolling-chair or in arms. The body is to be protected from hot and cold atmosphere and accidents of all kinds. A patient should not be transferred any great distance, and the atmosphere through which he is to pass should be of uniform temperature with that of the room which is to be occupied. This being an impossibility when the elevator is used, together with numerous other dangers connected with it, should be sufficient reason for dispensing with its use altogether, when possible.

The effects of heat and cold perhaps affect the organs of respiration, their results being irritation, hyperemia, congestion and inflammation, either one of which produces cough and more or less secretion. Any effort to expel it by coughing causes much distress. That these conditions may best be avoided, the room in which the patient is to be received should be selected free from draught. This is best accomplished with one having a southeast exposure, well ventilated and with an abundance of sunshine.

The bed should be especially constructed for the surgical care of the patient, high, narrow, and of metal, the entire outfit of bedding washable.

The selection of a *competent nurse* should be made with reference as to ability and personnel. Her clothing should be of soft fabric, void of starch, her shoes with low heels—in every respect practical and perfectly clean. The relations of the family and attendants should be most agreeable and subservient to the welfare of the patient.

In assuming this care, one becomes a physical, social, domestic and financial guardian.

Diet is one of the most important features in after-care. Upon it depends progress in the weight and physical condition of the patient. Pure water, warm or cold, may be given immediately or a few hours after operation. Milk or soft-boiled eggs come next in order to albumen-water, while broths and buttermilk will thereafter serve an excellent purpose. With all

patients that have been narcotized there is more or less gastric disturbance, and there is some hesitancy in permitting food to be taken before the end of twenty-four hours—not then if vomiting persists. Milk, toast and solid food should precede anything more difficult to digest after twenty-four hours have elapsed. It is the prime duty of all who care for the sick to see that the patient receives proper food, properly prepared and served in an appetizing way. It is equally important to see that the patient receives nothing, regardless of what others may or may not endorse. Attendants sometimes commit dangerous and fatal indiscretions by their inability to withstand the patient's pleadings for inappropriate food. Too much emphasis cannot be placed upon the importance of proper feeding.

The X-ray and radium have been so enthusiastically recommended, alone or combined with surgery, in the treatment of all forms of neoplasms of the thorax and its viscera, that it is becoming that they be given favorable mention, even though their influence in these tissues has not been well established. Their use is indicated in the inoperable benign and malignant growths, and though but little has been accomplished with either, the results warrant their continued and energetic use. The technique for using them can be known to comparatively few only, so that it will not be considered herein for after-treatment.

Mercury, alone or combined with the iodides, being almost a specific for syphilitic lesions, should be given in some form or way after surgical operations for any such lesions in the thorax or its viscera. They are indicated in operations and injuries of all kinds upon syphilitic and sarcomatous subjects, and should be given to the maximum influence by inunctions, hypodermic injections of gray oil, or by the mouth or rectum. Such a course of medication will prevent delayed union of fractured ribs, costal cartilages or sternum, and cause them to become united after all other means have failed.

Serum, alone or combined with surgery or any other remedy, has been of little if any avail in the treatment of any form of neoplasms of the thorax or its

viscera. However, as surgery and its combined treatments for malignant growths in these tissues has failed of material accomplishment, it is proper that serum and all other supposed remedies for their cure should be applied in after-care.

The vacuum chamber seems a possible means for making intra-thoracic surgery more perfect and with less mortality than by any other method. The principle is especially adapted to the thorax, and the experimental investigations, together with its practical use on man, justify this statement. While the cumbersome character and complicated mechanism of the chamber, together with the special technique in using it, will delay its general usefulness, there is no reason why surgical institutions should not possess one, and the surgical attendants be made familiar with its use. It is not only essential in emergencies, but, if practical, would be the method of choice.

Human health and life are the most sacred of all possessions, whether they exist in the person of a giant or that of a pigmy, or whether found in a mansion or in a tenant-house. There should be no favoritism, for Nature is not a respecter of persons, and the surgeon should not be so. Unfortunately, however, there remain classes, but the lines of distinction are rapidly being effaced, and it will not be long until equal rights pertaining to surgery and physic will become international. The rapid progress in surgery is sometimes bewildering, even to those most aggressive, and now that so many revelations have been made to give inspiration, there should be no hesitancy on the part of any possessing a license to practice the art of physic, to do his duty and assume the responsibility of doing or having done any surgical operation necessary to be done upon the thorax and its viscera.

CHAPTER IV.

LOCAL VERSUS GENERAL ANESTHESIA.*

The great achievements in surgery during the last seventy years have been due to four factors, given in the order of their importance:

1. General anesthesia.
2. Asepsis.
3. Technique.
4. Local anesthesia.

General anesthesia was in the beginning, is now, and always will be, practiced with the greatest anxiety, though it is absolutely necessary in certain cases, because of the desperate surgical trauma and conditions which necessitate its infliction.

Asepsis, first practiced by Lister in 1870, was the next great step to general anesthesia in surgery. It has been the means of more daring and radical work than had ever been thought possible. The surgeon does his work with greater refinement, and when made perfect there is no operation that he need hesitate to do without infection.

Technique is as old as surgery, having gradually evoluted into a most perfect system, not, however, due to the efforts of one, but to all operators in general. The various techniques have been combined to make one composite. That which has been developed through

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*Read by title before the Thirty-fifth Annual Session of the Mississippi Valley Medical Association, St. Louis, Mo., October 12-14, 1909.

the influence of general anesthesia had its individuality; that developed by both general anesthesia and asepsis another; the technique developed through general anesthesia, asepsis and local anesthesia still another, until now that at hand surpasses anything that has ever been known in perfection and simplicity.

Local anesthesia has not of itself many serious objections as to dangers. Its rapid development has been greatly due to the dangers of the first and the advantages of the second and third factors herein mentioned.

Anesthesia—want of feeling—may be partial or complete, mechanic, pathologic or artificial, temporary or permanent, local or general, each with or without loss of mental consciousness and local without constitutional disturbances.

Anesthetics, both local and general, alone or combined, given by an expert or a tyro, with or without organic lesions, in health or disease, to a giant or a pygmy, in young, middle or advanced life, are dangerous; but the greatest of these are general anesthetics, and, while they may never be supplanted by local anesthetics, they should be when possible. The dangers of all, except those without constitutional effects, are best recognized in idiosyncratic effects, so that their limitations should be well guarded as to the amount of drug, environment, purpose and degree of work, and time required to do it, the time always being minimized.

Timidity and sympathy are too prevalent when safety should dominate. The patient should assume some responsibility with pain, if necessary.

The term "general" is indefinite, because there are three methods for making anesthesia general. One by inhalation, causing loss of mental consciousness; one by absorption, with loss of mental consciousness, and the other by spinal injection, without loss of mental

consciousness. It is, therefore, important that anesthesia be considered from four viewpoints:

1. General anesthesia, with loss of mental consciousness.
2. General anesthesia, without loss of mental consciousness.
3. Local anesthesia, without loss of mental consciousness.
4. Local anesthesia, without constitutional effects.

General anesthesia with loss of mental consciousness was second in importance to ligaturing vessels in the great evolution of surgery. The time required by inhalation, both during and after an operation, the unpleasant and uncontrollable effects and mortality, have prompted investigation for their betterment and substitution, all of which have been reasonably well accomplished.

During the second century Rabbi Elieser (Ben Simion, 139-169), the Talmud relates, was taken to the house of Shisha Sama Deshinta and given a sleeping potion. An abdominal section was made and much fatty tissue removed. (Baba Messiah, 83, B.)

The drug used for this purpose is unknown, but probably was mandragora, for it was at that time a popular and effective means of relieving pain. This is the first recorded mention of any kind of anesthesia.

APPLYING GENERAL ANESTHETICS WITH LOSS OF MENTAL CONSCIOUSNESS.

General anesthesia is much longer in duration, consequently there is a great temptation to waste time, which adds greatly to risk from shock due to trauma and the anesthetic.

Following are the general anesthetics in the order of their popularity (mental consciousness not retained):

1. Ether.
2. Chloroform.
3. Nitrous oxide.
4. Alcohol, chloroform, ether.
5. Ethyl chloride.
6. Ethyl bromide.
7. Hyoscin, morphine, cactin.
8. Combinations.
9. Hypnosis.
10. Somnoform.
11. Keelene.
12. Veronal and chloroform.

Ether was discovered by Valerius Ceordius, 1540. He called it oleum vitrioli dulce. Djabar Yeber, an Arabian chemist, discovered it independently. Dr. Michael Morris discovered the method of manufacturing it, while Dr. C. W. Long, a dentist of Jefferson, Jackson County, Ga., employed it for a minor operation in 1842, and Dr. T. G. Morton gave it to a patient for surgical operation by Dr. Warren, Boston, Mass. However, Dr. Richard Pearson, 1795, gave it by inhalation to patients afflicted with pulmonary tuberculosis.

Ether is the most generally employed, and is said to have a mortality less than any of this group, but its effects upon the kidney and respiratory tract are probably the most harmful. These, together with the great amount of time necessary to secure its effects, and unpleasant effects immediately following its administration, are all sufficient to warrant a substitute. Deaths due to ether seldom occur during its administration. They usually occur within ten days, and are due to acute bronchitis, pneumonia, pleurisy, endocarditis, nephritis or acute yellow atrophy. Mortality, 1 in 10,000.

Gwathmy has suggested (1910) and has succeeded

in producing ether anesthesia by introducing four ounces of sulphuric ether mixed with two ounces of olive oil and two drachms of paraldehyde into the rectum forty minutes before operation. He has found it satisfactory in every way for operations upon parts of the body with the exception of the abdominal viscera. General distention of the intestines with ether gas renders it objectionable for this purpose.

Chloroform was discovered in 1831, independently by Liebig, Sonbieran and Guthrie. Gumas discovered its chemical composition in 1834. Flourens, in 1847, experimented with it, and Jas. Y. Simpson used it for surgical operation November 15, 1847. Its use is second in frequency. The mortality is generally believed to be three times greater than ether. This is probably so, counting the immediate deaths due to its use, but not so if the deaths ensuing due to ether are considered. Its effects are shorter, less serious, as a rule, and with less acute infection of the endocardium, kidney and respiratory tract. Mortality, 1 in 6,000.

Deleterious effects of chloroform are: Hemolysis in the liver; insult to parenchymata, especially that of the kidney; production of albumin, casts, and various abnormal urinary sediments, all of which indicate mild nephritis, usually temporary. Urine is diminished in amount in both man and animals, but soon becomes greater than before chloroform is administered, all of which is increased (sometimes anuria) when the amount of chloroform, which acts directly upon the glandular epithelium, is increased.

Autopsies show degenerative changes in the tubuli contorti, which explains the cause of death several days after anesthesia with this drug. Thus diuresis should be produced immediately before and after the use of chloroform and the state of anesthesia of short duraton. (Stankiewicz, Paris, 1908.)

Nitrous oxide was discovered in Dr. Beddoe's Institute, and reported by Davy, 1799, and demonstrated by Allen at Guy's Hospital, 1800. Horce Wells, a dentist at Hartford, Conn., 1844, was the first to use it in man. It has the shortest duration of any of the general anesthetics, and when employed alone should be limited to minor operations of short duration. It is popular when followed by one of the other general anesthetics of longer duration. Acute infection, gastritis and acute yellow atrophy have not as yet been attributed to its use. Mortality, 1 in 100,000.

Crile (personal communication, June 24, 1909) states: "Nitrous oxide and oxygen I have used very frequently in the last few years. I find it an efficient anesthetic, difficult to administer, and having many very great virtues. It can only be given in the hands of a nitrous oxide expert."

Titer reports 13,000 successful administrations of nitrous oxide and oxygen without a death.

Alcohol-chloro-ether.—First used about 1862. Mortality, 1 in 17,500. Its advantages are best described in the following personal communication:

Dayton, O., June 23, 1909.

Dr. B. M. Ricketts.

My dear Sir:—Your favor of 21st, regarding A. C. E. mixture is at hand. I did not originate the mixture, but have had often, before this, to deny its paternity. About 1862—I can not give the exact date—the Medico-Chirurgical Society of London recommended it. It had just become apparent that chloroform was not the ideal anesthetic hoped for. A number of deaths had occurred, and that society recommended as substitutes three mixtures—the A. C. E.—equal parts of ether and chloroform and one other which I do not remember—all practically dilutions of chloroform. The action of this society may be found in a file of the Medical Times and Gazette, which I took at that time.

I felt that, conscientiously, I must abandon the use of chloroform (except under certain conditions), which was

to me a great trial. But, feeling so, I adopted the A. C. E., and was so pleased with it that I think I should return to it were I again to enter practice, even in view of the improved methods of administration of ether now in vogue.

The A. C. E. is not perfectly safe. (I should have said that I based my advocacy of A. C. E. on practicability, not on superior safety to ether; that it is far safer than chloroform, I am sure.) No anesthetic is. I have some fatal cases noted from reading recorded in my note book. There has been one death in St. Elizabeth Hospital in this city in thirty-four years, where it was formerly exclusively used. I base my advocacy of it on its practical advantages over ether—manageability, promptness of action, not upon greater safety.

There have been many debates about the A. C. E. It was objected that the ether, being more volatile, would evaporate first, leaving on the sponge or in inhaler pure chloroform, or would be given when the administrator thought he was giving the mixture. This, to me, is nonsense. If true of the mixture exposed in a vase, it could not occur under the conditions of administration. To meet this, it was urged by friends of the mixture that it was a new combination and not a mixture. This is a chemical question. I had at one time chemical authority in its support.

The A. C. E. is given very rarely in this region now. Possibly the improved methods of administering ether, above alluded to, have caused this, but as I have withdrawn from practice for a good many years I can not be sure. Dr. James A. Duncan, of Toledo, wrote me recently that he had given it three thousand times without accident. I could not give an estimate of the number of times I administered it and saw it administered. I had a couple of narrow escapes.

I am fraternally and truly yours,

J. C. Reeve.

Ethyl chloride (C_2H_5Cl) is a colorless, volatile and inflammable liquid, having a low specific gravity of (0.9214 at 0° C.) and boiling at 10° C. It is employed as a freezing mixture for local anesthesia, and by inhalation for general anesthesia. As regards its safety, statistics seem to show that the mortality is 1 in 12,000 (Lotheisen, Ware). In a series of cases reported by

Lee, from the Pennsylvania Hospital, its mortality was considerably higher, four deaths occurring in 5,575 cases, but all the fatalities in this series should not be attributed to the anesthetic.

Ethyl chloride possesses the following advantages: It is not unpleasant to take, its inhalation is attended with but little excitation, and anesthesia ensues within a minute, while the inhalation may be continued indefinitely. Owing to its low boiling point and high volatility, ethyl chloride is eliminted from the body very rapidly, the patient's recovery is exceedingly prompt, and is associated with but few after-effects. For brief anesthesia it may be given in the upright posture.

The anesthetic is administered by spraying under an ordinary chloroform mask covered with oiled silk, or through some special apparatus, such as the Ware inhaler. It is given to better advantage with a closed inhaler provided with a rubber bag for rebreathing, such as the Stark or the Iglauer inhaler.

Ethyl chloride is especially valuable for brief anesthesia during minor surgical procedures in clinic or office practice. Owing to the incomplete muscular relaxation of the patient, it is not employed to any great extent in abdominal surgery.

The chloride of ethyl may be advantageously employed as a preliminary to ether, since the transition from the chloride to the ether anesthesia takes place very rapidly and the first stage of etherization is entirely eliminated. Owing to the rapid action of ethyl chloride, the anesthetist must be particularly alert when employing this powerful drug. (Iglauer.)

Ethyl bromide (hydrobromide ether, bromohydric ether) is a colorless, volatile liquid with a fagrant odor and a hot saccharine taste. It was discovered by Serullus in 1827. It has a specific gravity of 1420 and boils at 104° F. It was first used as an anesthetic by Nun-

nely, of Leeds, in 1865, and often used as an anesthetic until 1880, when it was almost completely discontinued on account of the death of two patients, one of Dr. Lewis, Philadelphia, and the other of Dr. Marion Sims, of New York, both of whom had used it extensively. It is now seldom employed as an anesthetic; the mortality is 16 in 60,000.

Hyoscine-Morphine-Cactin.—This means of anesthesia grows in popularity, and seems destined to a permanent place in the class of anesthetics. Like others, it has its advantages and disadvantages, which can only become known with time and experience. Its objectionable features are demonstrated to be prolonged unconsciousness, anesthesia and high mortality. A small amount of chloroform or ether is necessary to make its effects more certain. The following statement by Dr. Emory Lanphear (personal communication) is self-explanatory:

"I think it was late in 1903 when I first used the scopolamine-morphine combination in surgery. After some seventy operations (with only one bad scare), I was about to abandon its use when Abbott called my attention to the fact that hyoscine and scopolamine have the same chemical formula, but that while the scopolamine is often impure and dangerous, the hyoscine, from hyoscyamus, is always uniform, free from impurities, and as free from danger as any hypnotic agent of power can be. As early as 1904, I began using a combination of one-fourth grain morphine sulphate with one one-hundredth of a grain of pure hydrobromide of hyoscine. It acted so uniformly and so satisfactorily in all cases except those with weak heart that I wrote to Abbott to make me a few hundreds of tablets. He did so, and Dr. Waugh suggested that digitalin be added to overcome the objection to the anesthetic in the weak-heart cases. It did not do well. Then I had some made with strychnine; it was worse. Then we tried sparteine and several other combinations. After several months' experimentation we finally evolved the formula now used:

Morphine hydrobromide, one-fourth.
Hyoscine hydrobromide, one-hundredth.
Cactin from cact. grand., one-sixty-seventh.

"About six million doses of the anesthetic have been used up to date with only six deaths recorded so far as I can find, and in only one was the cause of death absolutely proven to be due to the anesthetic. And yet its critics say, 'It isn't proven to be safe!'"

Combinations.—Ether and chloroform are sometimes employed alternately, ether and nitrous oxide, chloroform and nitrous oxide, ethyl chloride and nitrous oxide, ethyl chloride and chloroform, and sometimes ethyl chloride and ether. It is always a question, however, whether such use is rational, because the statistics upon the subject are vague. It is probably better to learn how to use any one of them, and continue to do so.

Hypnosis.—The earliest history is that of the Miyas of Yucatan; however, not until the days of Mesmer was it satisfactorily known to be a means of anesthesia. During 1772-1790, he demonstrated many facts to show that teeth could be extracted, foreign bodies removed and minor dislocations reduced under its influence without pain. The French people were in a psychic state, which pemitted of them being carried beyond tolerable reason. Personally, it has been demonstrated to be a means of accouchement and reduction of dislocated fingers. Public sentiment, however, looks upon it with disfavor and skepticism.

I-Em-Heter, an Egyptian, 4500 B. C., meaning the "bringer of peace," evidently was one of the earliest, if not the earliest, psychotherapists. He was probably familiar with hypnosis, for the Miyas, of Yucatan, practiced it about or before that time. There is sufficient evidence to show that the inhabitants of the two countries had social and commercial relations.

Dr. Louis A. Dugas, state of Georgia, was the first in this country to apply the test of surgery to animal magnetism, or mesmerism. In 1845, he operated three times on a female during the "mesmeric sleep" for a recurring carcinoma of the breast. In the third operation the axillary glands were also removed. The patient gave no indication whatever of sensibility. (*Southern Medical and Surgical Journal*, March, May and September, 1845.)

Somnoform is the trade name of a mixture of ethyl chloride, 60 per cent.; methyl chloride, 35 per cent.; ethyl bromide, 5 per cent. It was devised by Roland, of France, in 1901, and was supposed to enter, be transmitted in and make its exit from the body in much the same way as oxygen. It is used extensively in Europe and to some extent in this country, but the use of it has been confined almost entirely to dentistry.

Veronal-Choloroform was suggested by Pokotilo (*Chirurgie*, July, 1905) and since exclusively employed by him. It occurred to Pokotilo that veronal would be valuable because (1) it has the power of producing sleep without any injurious accompanying symptoms; (2) it is a derivative of urea and contains, therefore, two amido groups (NH_2), the latter acting like ammonia as a heart stimulant. It was shown that it also fulfills the above mentioned demands. One and one-half to two hours before operation, in 1.0 gm. dose, the following was observed: Patients either go to sleep or are very drowsy, and, therefore, indifferent to their suroundings or to the coming operation. Sometimes too long a time elapses before giving the chloroform and they wake up. The stage of excitement is shorter and milder, the quantity of chloroform less and the after-effects less marked. Vomiting is rare.

GENERAL ANESTHESIA WITHOUT LOSS OF MENTAL CONSCIOUSNESS.

Discovered and employed by Dr. Leonard Corning, Canton, O., 1885. Cocaine for this purpose has been one of the greatest innovations in the category of anesthetics. It has many advantages over local and general anesthesia with loss of mental consciousness. Its disadvantages are complicated technique and high mortality, but it gains in popularity as technique and limitation are better understood.

General Anesthetics (Mental Consciousness Retained).—(1) Cocaine; (2) strychnine and stovaine.

Cocaine is the *sine qua non* of anesthetics for spinal anesthesia. Of its many forms, the tropa- and novo-cocaine are less toxic. While their effects may be local or general, they are especially applicable for spinal anesthesia. They are desirable in many operations, both below and above the diaphragm, especially in the aged, and when combined with sodium chloride, alcohol, adrenalin or cannabis indica are more effectual.

Dr. J. H. Jacobson, Toledo, O., June 7, 1909 (personal communication), states that he has used spinal anesthesia forty times. Three times the needle could not be introduced into the canal. Of the remaining thirty-seven in two no anesthesia was produced; of the remaining thirty-five, nine complained of some pain at the end of the operation, and in five cases a small amount of general anesthetic was used to complete the operation. Tropa-cocaine was used twenty-one times and stovaine sixteen times. Anesthetic used was first Merck's tropa-cocaine, 5 per cent. solution, or stovaine (Billon) 4 per cent. in 10 per cent. alcohol. There was one death which might be attributed to the anesthetic.

The site of injection was usually the third or fourth lumbar vertebra; time to produce anesthesia, from two

to twelve minutes. The average in thirty cases in which the time was recorded, was six minutes and forty seconds; height of anesthesia in twenty-two cases was oberved to be at or above diaphragm, and in a number of instances mid-sternum. During operation some vomiting was present in five cases, three cases headache, one severe and two slight. In twenty-six cases, duration of operation was recorded; in fifteen of these cases the operation lasted more than one hour, and in one case one hour and forty-five minutes. The last eleven cases were all complete successes, all under tropa-cocaine.

In the thirty-seven recorded cases sixteen were forty years or less, five between forty and fifty years, five between fifty and sixty years, six between sixty and seventy years, five were seventy years or above. The youngest was eighteen and the oldest eighty years.

The case mentioned above, in which the patient died, was an operation for tuberculous peritonitis, having been operated three or four months previous. She was weak and emaciated, pulse very feeble. She was given 1.5 c.c. of 4 per cent. stovaine in 10 per cent. alcohol; anesthesia was complete in about eight minutes. As the incision was being made patient became pale, vomited, and pulse became feeble, soon imperceptible, but became stronger, pulse about 60 per minute, under whisky by mouth and strychnine 1-30 gr. hypodermically, soon becoming weak again; shortness of breath, "air hunger" and very pale. No response to hypodermic of strychnine, whisky or camphor; artificial respiration was continued for one hour.

Strychnine and Stovaine.—A combination reported by Bannyryall, of Bucharest, June 1, 1909, is a substitute for cocaine, but so little is known about it that nothing definite can be reported. When injected into

the spinal canal its effects are said to be similar to cocaine and employed for the same purposes.

Dr. W. J. Mayo, Rochester, Minn., June 4, 1909 (personl communcation), states: "We never use spinal anesthesia."

Dr. Hugh H. Young, Baltimore, Md., June 4, 1909, says: "I have used spinal anesthesia fourteen times; the oldest patient was ninety-two year old. There have been no fatalities, and, as a rule, the method worked remarkably well. There were three cases, however, in which there was marked shock following the operation, which I thought was probably due to the cocaine. About one-fourth of a grain was used in each of these cases. Perhaps if less had been used, or if some other drug had been used, there would have been no shock."

Dr. Hesler, New York City, reports a case in which death resulted from infection of the spinal fluid.

The dangers of cocaine are minimized by the use of one-quarter grain sulphate of morphia injected subcutaneously one hour before the cocaine is administered in any way, without lessening its anesthetic effects for any purpose.

Forster, Kansas City, Mo., says as much as three grains of tropa-cocaine may be safely used for this purpose. In a personal communication, June 4, 1909, he says that he has used cocaine for spinal anesthesia three thousand times without any deleterious effects. (Also reprint, *Journal American Institute of Homeopathy*, March, 1909, two thousand times.)

Ferguson, A. H., Chicago, July 12, 1909 (personal communication): "I never could subdue my conscience to the point of allowing myself to use spinal anesthesia."

Spinal anesthesia will probably not soon, if ever, supplant general anesthesia, because of its higher mortality. However, the effort to have it do so is so great

and successes so numerous that it may at any time become the realization of the scientist's dream.

One and one-half grains of crystals in a sterile solution injected into the spinal canal will usually answer every purpose. Sometimes one or two drachms of the spinal fluid is first removed through a needle and received in a sterile tube. To this is added sterilized crystals of novo-cocaine. When dissolved this fluid is returned through the needle, the point of which has remained in the canal, the object being not to increase or diminish the amount of fluid within the canal.

Local anesthesia without loss of mental consciousness has been attemptd for the last half century, but not until Koller's discovery of cocaine was any method satisfactory; since than a number have been discovered, which are more or less so. It is practically without mortality, is the most common and satisfactory, and is especially desirable when general anesthesia, with or without loss of mental consciousness, is contraindicated.

Local Anesthetics (Mental Consciousness Retained).—(1) Cocaine hydrochlorate; (2) cocaine sulphate; (3) novo-cocaine; (4) tropa-cocaine; (5) eucaine; (6) ethyl chloride; (7) adrenalin; (8) cold water; (9) cataphoresis; (10) sinusoidal; (11) alypin.

Cocaine was discovered by Koller in 1884. The sulphate was the first of its many forms to be used for anesthetic purposes, but it was soon followed by hydrochlorate, eucaine, tropa- and novo-cocaine.

Personally, it was a pleasure to see what was said to be the first operation in the United States with cocaine (enucleation of an eye), by Dr. D. B. St. John Roosa, about October 15, 1884. The drug then sold for $1.50 per grain, but it now sells for one-half cent

(*Continued on page* 17)

a grain. Its usefulness has been advanced by refinement, rendering its effects, which are transient, less irritating and poisonous. Of the number in this group, cocaine in its various forms is the one selected, because most universally employed, alone or combined with other drugs.

The following letter is self-explanatory:

My dear Doctor Ricketts:

Up to 1884, as far as I know, the only kind of local anesthesia known and used was Richardson's ether spray anesthesia, practicable only for small, superficial and instantaneous operations. During the time I was an interne in the General Hospital of Vienna, I had had training in various laboratories, more especially in the experimental pathological laboratory of Stricker, where good animal experimenting was done. It was my intention to devote myself to ophthalmology, and I had heard my teacher, Arlt, speak frequently of the impracticability of utilizing general anesthesia for eye operations, because one had to forego the co-operation of the patient, and also on account of the undesirable after-effects which usually followed. It was then that the idea came to me that a local anesthetic for eye operations would be a great boon. I experimented with various substances from which I thought a local anesthetizing effect on the eyes of animals might be expected—bromide, chloral, morphine—with no success, and after a time give up these experiments.

Niemann, an assistant of the renowned Woehler of Goettingen, had extracted from coca leaves imported from South America an alkaloid which he called cocaine, and the drug was being experimented with, in view of the romantic stories of the use the Indians made of the herb to heighten their muscular endurance and exertion. The experimenters all called attention to the fact that cocaine benumbed the tongue when eaten, and one of them, Auref, a Russian, working in Rossbach's laboratory in Jena, went so far as to say that the anesthetic properties of cocaine might be utilized some day for practical purposes. When studying Worthnagel and Rossbach's Pharmacology I had un-

derlined this passage for myself. It happened at that time that a young physiologist of great prominence and promise, suffering from morphinism, was under the care of Dr. Joseph Breuer, assisted by one of my colleagues, Dr. Sigmund Freud, the neurologist, later founder of the school of psychanalysis. Cocaine was one of the drugs they tried on Prof. F., as this has been employed in America for the purpose of counteracting the morphine habit. This led Freud to an investigation of the physiological effects of cocaine in which I helped him. We would take the drug internally in powder form, at stated intervals, and afterwards measure our muscular strength with the dynamo-meter.

Upon one occasion another colleague of mine, Dr. Engel, partook of some with me from the point of a pen-knife, and remarked, "How that benumbs the tongue!" I said, "Yes, that has been noticed by everybody who has taken it," and in that moment it flashed upon me that I was carrying in my pocket the local anesthetic which I had searched for some years earlier. I went straight to the laboratory, asked the assistant for a guinea pig for experiment, made a solution of cocaine from the powder which I carried in my pocket-book, and instilled this into the eye of the animal. After a short period of irritation, I found I could touch the cornea with a probe, scratch it with a needle, burn it with heat, and found it also insensitive to faradic electricity. After experimenting on animals a few days, I instilled it in my own eye and in the eyes of some of my colleagues for demonstration.

Dr. Brettauer of Trieste, at my request, brought the matter before the medical profession at a meeting of the German Ophthalmological Society at Heidelberg, where the demonstration created quite a stir.

Early in October I read a paper on the subject before the Imperial Society of Physicians in Vienna, which is the only paper I have published on the subject. I limited my studies to the effects of cocaine on the eye, because of my original interest in this direction, though I was sure it would find usefulness in other branches of surgery. At my suggestion Dr. Jellinek, assistant of Schroetters in the laryngological clinic in

Vienna, worked out the effects of the new drug on the larynx.

It is still in the memory of many physicians how the knowledge of the new drug spread and its usefulness was broadened; how this gave an impetus to the coca industry in Peru and Bolivia and to the extraction of the alkaloid in the chemical factories in Germany and the United States.

Since then other substances have been tried and used to replace cocaine, but curiously enough not one has been found which possesses sufficient advantage to be generally adopted as superior to cocaine, and to this day the latter is used more than all the others combined.

CARL KOLLER, M.D.

New York City. Aug. 25, 1915.

The technique for its use is now so well perfected that any one familiar with it should not hesitate to employ it with the greatest assurance of both efficiency and safety. Wound infection resulting from the needle and solution used for local anesthesia sometimes occurs, but it need not do so if the proper precautions are taken. Defective technique in other steps of the operation should not be attributed to the injection.

The following operations represent proximally some personal experiences with cocaine subcutaneously injected, without any unpleasant results; a few equally good results have been obtained by blocking the nerve. Spinal anesthesia is not represented for the want of experience in technique. That has been left for others to relate.

1.	Amputation, forearm	2
2.	Amputation, upper arm	4
3.	Amputation, fingers	Numerous
4.	Amputation, thigh	10
5.	Amputation, lower leg	11
6.	Amputation, toes	Numerous
7.	Amputation, cervix uteri	2
8.	Amputation, scrotum	Numerous
9.	Amputation, male erectile body	
10.	Amputation, breast	25
11.	Amputation, coccyx	Numerous
12.	Amputation, female erectile body	2
13.	Amputation, ear	3
14.	Appendectomy	10

15. Appendical abscess 8
16. Aspirations .....Numerous
17. Colostomy 8
18. Closure of colostomy..... 3
19. Cholecystotomy 6
20. Cholecystectomy 1
21. Circumcisions .....Numerous
22. Cystotomy (urinary), stone..... 1
23. Cystotomy (urinary), removal catheter..... 1
24. Double orchidectomy 14
25. Dislocations of joints (reductions)..... 3
26. Enucleation of eye..... 1
Excision, coccyx .....Numerous
27. Excision, ribs 10
28. Excision of metacarpal bones..... 6
29. Excision of metatarsal bones..... 3
30. Exploring superficial and deep soft structures..Numerous
31. Exploring abdominal cavity..... 20
32. Exploring lobe of lungs..... 2
33. Excision, cutaneous neoplasms.....Numerous
34. Fracture, reductions 6
35. Gastrotomy 1
36. Herniotomy 30
37. Hemorrhoids .....Numerous
38. Hepato-omentopexy 3
39. Hydrocele .....Numerous
40. Ligation brachial artery..... 2
41. Ligation common carotid artery..... 2
42. Ligation external carotid artery..... 1
43. Ligation facial artery..... 1
44. Ligation femoral artery..... 4
45. Lipomata .....Numerous
46. Mastoidotomy 2
47. Nails, removal .....Numerous
Pyonephrosis, drainage 4
48. Osteomyelitis 6
49. Ovarian cysts 4
50. Parotid gland, removal..... 2
51. Plastic operation, nose.....Numerous
52. Plastic operation, lip.....Numerous
53. Plastic sundry cases.....Numerous
54. Plastic operation, eyelid..... 5
55. Prostatectomy 1
56. Renal fistula 4
57. Recto-vaginal fistula 1
58. Removal foreign bodies in subcutaneous tissue..Numerous
59. Rectal fistula .....Numerous
60. Single orchidectomy 20
61. Suturing tendon 3
62. Suturing cutaneous incisions, lacerations.....Numerous
63. Submaxillary gland, removal..... 4
64. Salivary concretion 3
65. Strangulated hernia .....Numerous
68. Trephining skull 3
69. Tubercular glands .....Numerous
70. Tongue (neoplasms) 4
71. Tubercular peritonitis 8

72. Tubercular bone ..... Numerous
73. Tenotomies ..... Numerous
74. Tonsilotomy ..... Numerous
76. Umbilical hernia 6
75. Tracheotomy 1
77. Urethrotomy (internal) ..... Numerous
78. Urethrotomy (external) ..... Numerous
79. Uvula (amputation) ..... Numerous
80. Vasectomy ..... Numerous
81. Vasiculotomy 1

Eucaine B, or the hydrochloride of benzol-vinyl diacetomalkamin, is frequently used as a substitute for cocaine. The crystals are soluble in water and are not decomposed by heating. It is free from irritating properties, and is less toxic than cocaine. It was introduced by Silex in 1897. Although anesthesia is not so complete or as long as cocaine, it is often used as a substitute for it, because of the absence of the unpleasant after-effects. A one or two per cent. solution is used for anesthetic purposes.

Reclus states, but does not give any reason for doing so, that it is unnecessary to have the patient lie down after the use of a one per cent. solution of eucaine B, as it is with cocaine. While eucaine B seems to have some advantages over cocaine, yet practically the disadvantages will probably prevent its being used as a substitute generally for cocaine.

Ethyl chloride is the simplest means of producing local anesthesia, and while not so effectual, is many times very satisfactory for minor operations where there are no inflammatory changes and where the length of time does not exceed five minutes, because it is very transient. It can not, for this reason, become general. Its influence must not be prolonged, because necrosis of the area to which it is applied may result. Its use is limited to integumentary structures.

Adrenalin does not possess a high degree of anesthetic value, but it is quite popular and effacacious in certain tissues, especially those in which it is desirable to contract the capillaries that blood may not obstruct the field of vision, and that the anesthetic drug may not become absorbed. Adrenalin intensifies the action of cocaine by suspending the circulation in a given tissue; it holds the anesthetic in place.

Electricity (*Cataphoresis*).—This means of producing anesthesia was discovered about twenty-five years ago, and has been a very effectual means of anesthetizing the teeth and forcing medicaments into the deep cutaneous structures. It has been a very popular method with dentists for filling teeth and destroying their nerves. Like the sinusoidal current, the paraphernalia and technique have prevented it becoming more generally employed.

Strychnia-Stovaine.—There is no available information upon its local effects or manner of securing them, except that it is injected into the spinal canal and that the strychnia overcomes the depressing effects of the stovaine.

Local anesthesia without constitutional effects is absolutely safe and very effectual under the conditions indicated. It has not received the good favor which it deserves, probably because of skepticism and the effort necessary to accomplish it. The difficulties attending the use of electricity are no doubt great factors in keeping it from becoming popular, while the use of cold water has not become so because of skepticism, want of technique and effort to become familiar with it.

Alypin, one of the more recent local anesthetics, was discovered by Poili. It is a glycerine derivative, being the monohydrochloride of benzol. It appears in the form of a white crystal powder, easily soluble in water and alcohol, and of a neutral reaction.

The solution of alypin can be sterilized by boiling for a short period (not over five minutes). It may be combined, without any change in its chemical and pharmacological properties, with the different suprarenal preparations, as well as with antipyrine. It does not undergo any change by boiling, and when a 5 per cent. solution is injected into the site of operation there is but slight toxic ecect, much less than that of cocaine; for this reason it is said to be better than cocaine.

Jaques says that he has recently had the opportunity of testing the qualities of a new preparation known as alypin. It is put forward as a substitute for cocaine in causing local anesthesia. A 2 per cent. watery solution was used, and the first experiment made on him-

self by instilling one drop of alypin in the right conjunctival sac and one drop of 2 per cent. cocaine in the left. The alypin caused slight vaso-dilatation and rather more smarting than the cocaine, but it quickly produced anesthesia and did not cause any dilatation. It has now been employed by him in a considerable number of slight cases, such as the removal of foreign bodies from the cornea, the cauterization of corneal ulcers, the removal of stitches from the conjunctiva, and in one case of iridectomy and cataract extraction. In all cases the anesthesia was satisfactory. In none was any dilatation of the pupil observed, but in most instances there was slight vaso-dilatation. In many instances, when using alypin in one eye, a drop of 2 per cent. cocaine was placed in the other, and the patient always stated that the alypin was slightly more painful. Alypin can be easily sterilized, since boiling for not longer than two minutes does not appear to alter its qualities.—*The Ophthalmoscope*, November, 1905.

Local Anesthetics Without Constitutional Effects:

1. Water.
2. Electricity (sinusoidal).

Water.—When injected subcutaneously, water has been known for forty years to be a means of producing local anesthesia. Many minor operations may be made painless if done rapidly and within a few minutes' time. The water should first be sterilized, then its temperature reduced to about freezing point, and the syringe kept in sterilized ice-water, that the water within it may be as cold as possible when it is injected into the tissues. The skin and deeper tissue may be made fairly non-sensitive in this way without infection.

Electricity (sinusoidal).—When the interruptions exceed 100,000 per minute, anesthesia of cutaneous structures is easily accomplished. Its duration, however, is limited to a few minutes, so that it is only appropriate in minor operations of short duration. These facts have been known for thirty years, but the paraphernalia and technique required is cumbersome and complicated, and for this reason has not become popular. Personally a number of operations by this

method of anesthesia have been done very satisfactorily, extending over a period of twenty years.

Methods for using local anesthesia without loss of mental consciousness vary somewhat, depending on the kind and locality of the tissue. They are given in the order of their frequent use:

1. Pledget.
2. Spray.
3. Syringe.
4. Needle.
5. Electricity.

Needle is employed when superficial methods are of no avail. The anesthesia can be limited to small areas, and the depth whatever may be desired.

Pledget is one of the most desirable means for anesthetizing mucous membranes, because it can be limited to small area.

Spray is more especially adapted to the respiratory and alimentary mucous tracts, and must be used with great caution because of the uncertainty of the amount absorbed.

Syringe.—Small canals, normal, artificial or pathologic, can best be anesthetized by injecting solutions through tubes attached to a syringe. The lachrymal and Eustachian ducts, urethra and various fistulas are especially adapted to its use.

Drop is the method of choice for anesthetizing the ocular and aural mucous membranes, because of the very small amount of surface; the constitutional effects are insignificant.

Mucous membranes are anesthetized with greater ease and frequency than any other tissue, and that of the respiratory tract requires less time and amount of the agent. There is no way of determining the amount of the drug actually absorbed, unless injected subcutaneously alone. For this reason great care should be taken whenever the drop, pledget, spray or syringe is used. The needle, both subcutaneously and intraspinal, gives better control of therapeutic effects, all depending upon the depth, amount of surface to be anesthetized, and purpose for which it is done. When anesthesia is desired in the urethral, vaginal, uterine, cystic,

rectal or lower ureteral mucosa, spinal injection is probably done with greater assurance of it being complete, but with greater danger of toxic effects. Therefore. its application with syringe, pledget, spray or needle, while not complete at all times, is safer and more generally employed.

Subcuticular, subcutaneous, intra-muscular and *spinal injections* are better in the body proper, other than the mucous membrane.

The drug should not be made to enter the general circulation, where its effects can in a measure be controlled with bandage, digital pressure and rapid work. Much that has been injected may be cut away and lost in depletion of the cut surfaces.

The dangers are eliminated as the extremities are approached. In these the amount of drug and time consumed are of less consequence, as its effects can be limited by rubber bandage applied immediately above the point of incision. This can, in a measure, be done with the scalp when the bandage is applied above the ears.

It is more difficult to eliminate its effects from the body structures, especially when applied between the clavicle and gluteal fold. Within these bounds nerve blocking and intravenous anesthesia are not applicable, especially intravenous injection.

In the cutaneous tissue the injections should be in the line of incision, subcuticular and deep, the amount depending upon the length of the incision and thickness of the integument. Usually not more than two grains is required, oftener less, for the largest neoplasms. Intravenous, spinal and blocking methods may also be employed in the cutaneous structures of the extremities.

Nerve blocking is many times the method of choice, and it should receive due consideration, especially when complete anesthesia is necessary in the extremities, without the dangers of constriction, and with general anesthesia, with or without the loss of mental consciousness, is contraindicated. A few drops of a 4 per cent. solution injected into the sheath of the brachial or sciatic nerve, after exposure through an incision,

made with subcuticular and deep injection, will produce complete anesthesia without the rubber bandage. This method is the simplest and safest, because of the direct and small amount required. Many of the nerves of the trunk may also be blocked by this method.

Intravenous anesthesia was discovered by Bier in 1908. It is contraindicated in arterio-sclerosis and diabetic gangrene, the dangers of which are increased by the bandages. It is only applicable in the extremities, where it can be employed with comparative safety. After the extremity has been made bloodless by elevation and massage, two rubber bandages are tightly applied, one immediately below the shoulder or great trochanter, and the other near the elbow or knee, but above it. The veins at once become prominent, and their contents completely isolated from the general circulation. The most prominent of these is selected and a 0.5 per cent. novo-cocaine solution injected into it between the bandages, and the operation completed before they are removed; not more than 80 c.c. should be used. If necessary, the lower one may be discarded, but the upper bandage may remain for an hour or longer, depending upon the condition of the member, and then removed slowly. This method is destined to a more general use, but its technique and indications must be well understood. It is immaterial whether a vein or an artery is already open, it may be used for the purpose, after first placing the bandage high up around the extremity. Injection into the ends of veins or arteries is an excellent way to produce anesthesia in partial or complete severance of an extremity for amputation or other surgical work.

Of the three tracts of mucous membrane that are available to local anesthesia, there is much in that of the alimentary tract that is unavailable.

LOCAL VERSUS GENERAL ANESTHESIA.

First. General anesthesia.
Second. Asepsis.
Third. Technique.
Fourth. Local anesthesia.

(a). General anesthesia with loss of mental consciousness.

(b). General anesthesia without loss of mental consciousness.

(c). Local anesthesia without loss of mental consciousness.

(d). Local anesthesia without constitutional effects.

GENERAL ANESTHETICS IN THE ORDER OF THEIR POPULARITY.

(Mental consciousness not retained.)

1. Ether.
2. Chloroform.
3. Nitrous oxide.
4. Alcohol-chloroform-ether.
5. Ethyl chloride.
6. Hyoscamine, morphine, cactin.
7. Combinations.
8. Hypnosis.
9. Ethyl bromide.
10. Somnoform.
11. Kelene.
12. Veronal chloroform.
13. Ether, vapor and air.
14. Hedonal.

GENERAL ANESTHETICS.

(Mental consciousness retained.)

1. Cocaine.
2. Strychnine and stovaine.

LOCAL ANESTHETICS IN THE ORDER OF THEIR POPULARITY.

(Mental consciousness retained.)

1. Cocaine hydrochlorate.
2. Cocaine sulphate.
3. Novo-cocaine, novocaine.
4. Tropo-cocaine.
5. Eucain.
6. Ethyl chloride.
7. Adrenalin.
8. Cold water.

9. Cataphoresis.
10. Sinusoidal.
11. Alypin.
12. Urea and quinine.

LOCAL ANESTHETICS WITHOUT CONSTITUTIONAL EFFECTS.

Water.

Electricity (sinusoidal).

Methods for using local anesthesia without loss of mental consciousness vary somewhat, depending on the kind and location of the tissue. They are given in the order of their frequent use:

1. Pledget.
2. Spray.
3. Syringe.
4. Needle.
5. Electricity.

METHODS EMPLOYED FOR LOCAL AND GENERAL ANESTHESIA WITHOUT LOSS OF MENTAL CONSCIOUSNESS.

1. Mucous membrane.
2. Subcuticular.
3. Subcutaneous.
4. Intramuscular.
5. Nerve-blocking.
6. Spinal injection.
7. Intravenous (for extremities).

STRUCTURES FOR LOCAL ANESTHESIA.

1. Mucous membrane.
2. Cutaneous.
3. Muscles.
4. Fasciæ.
5. Tendons.
6. Glands.
7. Blood-vessels.
8. Nerves.
9. Lymphatics.
10. Bones.
11. Head.

12. Neck.
13. Extremities.
14. Thoracic organs.
15. Abdominal organs.
16. Abdominal cavity.
17. Entire body with spinal anesthesia when done with cocaine or strychnine stovaine.

MUCOUS MEMBRANE.

Respiratory: Auditory, nasal, mouth, trachea, bronchial.

Genito-urinary: Urethral, vaginal, uterine, cystic, ureteral.

Alimentary: Esophageal, rectal.

EYE.

Operation: Iridectomy, myotomy, tenotomy, removal of lens, enucleation, retinotomy, retinectomy.

Indications: Foreign bodies, pterygium, strabismus, neoplasms, cataract, glaucoma, pathologic, glands, lacerations, detached retina.

Method: Drop, pledget, deep, spinal.

LACHRYMAL DUCTS.

Indications: Stricture, injuries, neoplasms.

Methods: Drop, syringe, spinal.

EARS.

Indications: Paracentesis, foreign bodies, neoplasms.

Methods: Pledget, spray, syringe, needle, spinal.

NOSE.

Operations: Turbinectomy, adenectomy, turbinotomy, septotomy, septectomy.

Indications: Neoplasms, foreign bodies, caries of bone, drilling antrum, deformities.

Methods: Pledget, spray, syringe, spinal, needle, cataphoresis.

MOUTH AND THROAT.

Indications: Extraction of teeth, tonsillotomies, tonsillectomies, uvulotomies, uvulectomies, neoplasms,

5. Prostate.
6. Parotid.
7. Submaxillary.

Operation: Excision, suture.

Indications: Neoplasms, fistulæ, cysts, lacerations, foreign bodies, concretions.

Methods: Subcuticular, deep, blocking, spinal, cataphoresis, intravenous.

NERVES.

Operations: Neurectomy, neurotomy, neurorrhaphy, anastomosis.

Indications: Lacerations, neoplasms, paralysis, transplanting, grafting.

Methods: Subcuticular, deep, spinal, cataphoresis, blocking, intravenous.

BONES.

Indications: Osteotomies, ostectomies, reduction of dislocations, direct fixation of bone, osteomyelitis, neoplasms, arthrotomies, arthrectomies, foreign bodies, trephine (long bones).

Methods: Subcuticular, deep, intravenous, spinal, cataphoresis, blocking.

HEAD AND JAWS.

Indications: Neoplasms, fractures, mastoidotomy, trephining, foreign bodies, cerebral abscess, meningitis, draining ventricles, draining arachnoid, cerebral hemorrhage, excisions.

Methods: Subcuticular, deep, spinal, cataphoresis

FACE AND NECK.

Operations: Excisions, suture, incisions, tenotomies.

Indications: Neoplasms, plastics, foreign bodies, cysts, deformities.

Methods: Subcuticular, deep, nerve block, spinal, cataphoresis.

EXTREMITIES.

Indications: Amputations, dislocations, fractures, gangrene, tuberculosis, osteomyelitis, neoplasms, deformities, aneurysms, grafting, transplanting.

Methods: Subcuticular, deep, blocking, spinal, intravenous, cataphoresis.

THORAX—RIBS AND CARTILAGES.

Operations: Thoracotomy, thorectomy, thorocoplasty.

Indications: Cysts, neoplasms, fractures, dislocations, necrosis, operations upon all viscera.

Methods: Subcuticular, deep, spinal.

VERTEBRAE.

Operations: Laminotomy, laminectomy.

Indications: Neoplasms, cysts, fractures, dislocations, deformity.

Methods: Subcuticular, spinal, deep.

THORACIC CIRCULATORY SYSTEM—HEART.

Operations: Cardiotomy, Cardiorrhaphy, valvotomy, valvectomy, valvopexy.

Indications: Abscess, foreign bodies, cysts, neoplasms, incisions, punctures, lacerations, repair, neoplasms, deformity.

Methods: Subcuticular, deep, spinal.

BLOOD-VESSELS.

Operations: Arteriotomy, arteriorrhaphy, arteriectomy, ligation, anastomosis, introduction of wire.

Indications: Incisions, lacerations, neoplasms, aneurysms, transfusion.

Methods: Subcuticular, deep, spinal, blocking, intravenous, cataphoresis.

PERICARDIUM.

Operations: Pericardotomy, pericardorrhaphy, pericardectomy.

Indications: Cysts, clots, foreign bodies, neoplasms, hemorrhages, incisions, lacerations, ruptures.

Methods: Subcuticular, deep, spinal.

PULMONARY SYSTEM—LUNGS.

Operations: Pneumonotomy, pnemonectomy, pneumonopexy, pneumonorrhaphy.

Indications: Foreign bodies, neoplasms, cysts, herniæ, gangrene, lacerations, incisions, ruptures.

Methods: Subcuticular, deep, spinal.

BRONCHUS.

Operations: Bronchotomy, bronchorrhaphy, bronchectomy, bronchoscopy.

Indications: Foreign bodies, neoplasms, lacerations, incisions, ruptures, gangrene.

Methods: Subcuticular, deep, spinal.

PLEURAE.

Operations: Pleurotomy, pleurectomy, pleurorrhaphy, decortication.

Indications: Cysts, neoplasms, foreign bodies, hemorrhages, incisions, lacerations, punctures, ruptures, pleural thickening.

Methods: Subcuticular, deep, spinal.

DIAPHRAGM.

Operations: Diaphragmotomy, diapragmorrhaphy, diaphragmectomy.

Indications: Cysts, neoplasms, incisions, lacerations, ruptures, gangrene, herniæ.

Methods: Subcuticular, deep, spinal.

LIVER.

Operations: Hepatotomy, hepatopexy, hepatorrhaphy.

Indications: Cysts, cirrhosis, foreign bodies, ruptures, hepatic stones.

Methods: Subcuticular, deep, spinal.

GALL-BLADDER.

Operations: Cystotomy, cystectomy, cystorrhaphy, anastomosis.

Indications: Empyema, concretions, neoplasms, lacerations, ruptures, strictures.

Methods: Subcuticular, deep, spinal.

SPLEEN.

Operations: Spleenectomy, spleenopexy, spleenorrhaphy, spleenotomy.

Indications: Cysts, neoplasms, lacerations, splenoptosis, gangrene, foreign bodies.

Methods: Subcuticular, deep, spinal.

PANCREAS.

Operations: Pancreotomy, Pancreectomy (partial), pancreorrhaphy, pancreopexy.

Indications: Cysts, neoplasms, concretions, lacerations, foreign bodies, ruptures.

Methods: Subcuticular, deep, spinal.

KIDNEYS.

Operations: Nephrotomy, nephrorrhaphy, nephrectomy, nephropexy.

Indications: Cysts, nephroptosis, concretions, neoplasms, lacerations, foreign bodies, anomalies.

Methods: Subcuticular, deep, spinal.

OVARIES.

Operations: Ovariectomy, ovariotomy, ovarian fixation, implantation, transplantation.

Indications: Cysts, neoplasms, displacements, adhesions, ruptures, emasculations, pregnancies (ovarian).

Methods: Subcuticular, deep, spinal.

FALLOPIAN TUBES.

Operations: Salpingectomy, salpingotomy, salpingorrhaphy, anastomosis, implantation, transplantation.

Indications: Cysts, neoplasms, pregnancies (tubal), ruptures, injuries, adhesions.

Methods: Subcuticular, deep, spinal.

STOMACH.

Operations: Gastrotomy, gastrostomy, gastrectomy, gastrorrhaphy, gastropexy.

Indications: Ulcers, stenoses, neoplasms, perforations, gastroptosis, lacerations, foreign bodies, concretions.

Methods: Subcuticular, deep, spinal.

INTESTINES.

Operations: Anastomosis, excision, colostomy, appendectomy, cæcostomy, appendecostomy.

Indications: Herniæ, obstructions, neoplasms, strictures, perforations, lacerations, angulations, foreign bodies, concretions, enteroliths, ileus.

Methods: Subcuticular, deep, spinal.

OMENTUM.

Operations: Omentotomy, omento-fixation, omentorrhaphy, omentectomy.

Indications: Neoplasms, strangulations, cysts, ruptures, visceroptosis, foreign bodies, concretions, gangrene.

Methods: Subcuticular, deep, spinal.

ABDOMINAL CAVITY.

Operations: Suprapubic section, vaginal section.

Indications: Pus, serum, blood, chyle, foreign bodies, feces, urine.

Methods: Subcuticular, deep, spinal.

Their advantages and disadvantages are canceled in the following parallel lines:

ANESTHESIA.

Local and General.	**General.**
Mental consciousness retained.	Mental consciousness lost.
Shock not necessarily great.	Shock necessarily great.
More skill, judgment and technique.	Less skill, judgment and technique.
Can not as well be used for all operations, especially upon the head, neck and on children and highly nervous persons.	Can be so employed.
Better adapted in many emergency major operations.	Not adapted in many cases.
Patients can sometimes aid in operations.	Can not do so.
Wound infection probably no more frequent.	
Must work rapidly.	Inducement to work slowly.
Can partake of food and water immediately after operation.	Can not do so; may be for several days.
Can control effects as a rule.	Can not do so.
Indicated in the aged, arterio-sclerosis, gangrene, diabetes, cardiac disease, shock and bronchitis.	Contraindicated in all.

General.	Local and General.
Narcotics or stimulants not so necessary.	They are frequently so.
Does not cause bronchitis, endocarditis, pneumonia, pleurisy, gastritis, vomiting, anorexia, cerebral hemorrhage, dilated stomach, acute yellow atrophy, retention of urine.	May cause any one or more of these.
Local and General.	**General.**
Mortality very small.	Mortality much greater.
Convalescence short.	Convalescence long.
Mortality small, except spinal; then it is higher.	Mortality greater in spinal; then it is less.

CHAPTER V.

INTRATRACHEAL INSUFFLATION ANESTHESIA.*

As early as the middle of the sixteenth century Vesalius I. recognized the possibility of aerating the blood, after the chest had been opened, by passing a continuous current of air through the lungs; while in 1667, Hook read before the Royal Society a paper entitled, "An Account of an Experiment Made by Mr. Hook by Preserving Animals Alive by Blowing Through Their Lungs with Bellows."

In his experiment, Hook, having laid open the entire thorax of a dog and removed the pericardium, sustained the animal's life, first by reciprocal inflation and deflation of the lungs, in imitation of normal respiration, and then by means of a constant current of fresh air under such pressure that all respiratory movements of the lungs themselves were suspended. Both methods were successful in continuing animation and the pulmonary circulation.

While mechanical respiration remained a valuable adjunct of laboratory experiment for almost 250 years, its failure as a human resuscitative measure in the practice of such surgeons as LeRoy of France, and Monroe and Dalrymple of England, forced the scientist, John Erichson, in 1845, to conclude that, "In spite of all the improvement and modifications of the technique and the methods of inflation by bellows, mechanical respiration never again came into favor and was speedily forgotten when the postural methods came into use."

Marshall Hall was especially severe in his condemnation of forced mechanical respiration by means

*An address, with demonstrations, delivered at the time of the International Clinic Week at the New York Polyclinic Medical School and Hospital, during the International Surgical Congress, April, 1914.

of bellows, and until 1887 the postural resuscitative methods of Hall, Sylvester, Schaffer, and Howard were extensively employed.

On July 23, 1887, Dr. George Edward Fell of Buffalo, N. Y., after all the postural methods of resuscitation had been tried and failed, by means of forced respiration saved the life of a patient who had taken twenty grains of morphine and some chloral hydrate, even after the pupils had dilated in the last stage of asphyxia. Within about three months following, Prof. Dr. Boehm of the Allgemeines Krankenhaus in Vienna saved the life of Dr. Langer by the same method.

Other successful cases of a similar character followed, and established a new epoch of artificial respiration. In practice Dr. Fell used an especially devised face mask and a trachectomy tube, and later an intubation tube, the invention of Dr. O'Dwyer, connected to a single bellows and provided with a coronet piston exit valve, by the manipulation of which inflation and deflation of the lungs could be made to duplicate normal breathing. In one instance, the case of Dr. Williams, reciprocal respiration was continued intermittently during four days, with recovery of the patient, and without any untoward pulmonary, laryngeal or systemic complications.

It was through the incentive given to artificial respiration by the introduction of Fell's method of "forced respiration," and his adaptation of etherization to the technique, that the surgery of the thorax, through its utilization, became a possibility. F. W. Parham, of New Orleans, was the first to successfully remove a sarcomatous growth from the walls of the thorax, using "forced respiration anesthesia" by the Fell-O'Dwyer method, for purposes of the narcosis and combating pneumothorax. The operation was performed under reciprocal breathing, and the chest walls were closed with the lungs fully inflated. Complete recovery of the patient ensued.

About 1896 the French surgeon, Tuffier, in association with Hallion, after exhaustive intrathoracic ex-
ntation under continuous insufflation, concluded

that, "the success of this method on animals justified its use in man." In 1902, Matas turned his attention to a solution of the surgical problems involved in pneumothorax.

Kuhn, of Cassel, who had made intubation a specialty since 1895, in 1905 came out with a positive differential method for compensating pneumothorax, based on insufflation by intubation. He at first closed the mouth tight, but in 1908 improved his previous technique by introducing two tubes in one, a narrow tube for inbound compressed air and a wider one for the exhaust. After many experiments on the human being, Kuhn found it advisable to keep the tube out of the trachea, and to stop it just below the larynx. While Kuhn demonstrated the pulmonary application of anesthesia by intubation to Czerny of Heidelberg, Trendelenburg of Leipsic, Angerer of Munich, and Lotsch of Berlin, visiting each of these surgeons personally, nevertheless the method was not favorably received for use in intrathoracic surgery on the human subject.

In 1908, Robinson of Boston intubated through the mouth to the bifurcation of the trachea, sending in air under pressure through a canula, and letting the exhaust escape by way of the remaining lumen of the trachea. Later Robinson investigated the Volhard-Sollman method of oxygen insufflation, by means of which, during animal experimentation, life could be sustained without distention of the lungs; but he was distracted from perfecting this or the air-insufflation technique by becoming interested in progressive improvements which he made in both the Brauer and Sauerbruch methods.

Mikulicz, however, must be credited with the first systematic investigation of the physiological problems besetting intrathoracic surgery. At his suggestion in 1903, Sauerbruch began a series of experimental researches, and in 1904 completed cabinets for intrathoracic surgery, using respectively positive or negative pressure.

While Sauerbruch soon discarded his hyperatmospheric apparatus in favor of his negative-pressure cabinet, Brauer, working independently, developed the

first positive-pressure chamber to come into general use. The apparatus devised by Karewski resembled closely that of Bauer, as did also the initial cabinets of Janeway and Green. The devices of Tiegel and Brat-Schmieden were essentially of the emergency or laboratory type, although an effort was made to adapt them to the more exacting requirements of intrathoracic surgery on the human subject.

What Carrel has termed the "classical type" (cabinet) of apparatus has found its apotheosis in the new intrathoracic surgical pavilion of Willy Meyer at the German Hospital, New York, in which it is possible to operate differential, positive or negative pressure at will.

Until the present popularization of intratracheal insufflation by the Meltzer-Auer technique, whatever real progress has been made in intrathoracic surgery on the human subject must be credited to the "classical style" of apparatus.

In 1908 Meltzer saw Sauerbruch doing intrathoracic surgery, and later witnessed some of Willy Meyer's operations at the Rockefeller Institute, and seeing both pleural cavities wide open and the animals continuing to breathe, but not trusting the evidence of his own eyes he went into his laboratory to verify the experiments. A year later, in association with Dr. Auer, he published an article on "Continuous Respiration Without Respiratory Movements." After Meltzer had perfected the technique of intratracheal insufflation in his laboratory, Elsberg, with the assistance of Yankauer, developed an apparatus for its use on the human subject, and personally administered anesthesia by this method for a successful thoracotomy performed by Dr. Lilienthal at Mt. Sinai Hospital in 1910.

Meanwhile, Morrison Davies, after a thorough investigation of all the intrathoracic apparatus and methods in vogue, perfected and used a hyperatmospheric device, combining both the advantages of the cabinet and intratracheal insufflation techniques, and to Elsberg, and Peck (New York) and Davies (London) belong the credit, not only of adapting intratracheal insufflation to the requirements of intra-

thoracic surgery, but also of demonstrating its value as a technique of narcosis in the surgery of the head and neck.

While the "classical type" of the cabinet and intratracheal style of apparatus are in apparent competition for supremacy, still each has its possibilities and its limitations, and further clinical experience alone will determine their respective utility in certain definite intrathoracic surgical procedures.

Physiological Considerations.—Progress in intrathoracic surgery has depended absolutely on the mechanical control of pneumothorax during the operative procedure. This mechanical control has varied in different methods from that of Hook, now represented by the Meltzer-Auer technique, in which the lungs for certain periods have been so distended by a constant current of air as to preclude more or less any respiratory movements, to that of Volhard-Sollman, in which the lungs have been allowed to collapse, while a current of oxygen sustained life.

However, for all practical purposes, reciprocal breathing, under manometrically controlled positive, negative, or differential pressure, has proven the only safe method of compensating pneumothorax during intrathoracic operations upon the human subject.

Any consideration of pneumothorax involves an understanding of some elementary facts of the respiratory mechanism. Respiration is made possible in the thorax of the human subjects by a partial vacuum existing in the pleural space after the contraction of the lungs during expiration. This vacuum is represented by a varying negative pressure of from 4 to 10 mm. of mercury. Consequently thoracotomy requires either positive-pressure insufflation, with or without respiratory movements, or autorespiration in the negative or differential pressure cabinet, to prevent the collapse of the lung resulting in dyspnea, displacement of the thoracic viscera, shock, and death.

With the body of the patient within the cabinet in which the air has been rarefied to approximately the negative pressure in the pleural cavity (4 to 10 mm.) and the head of the patient is outside the chamber,

permitting the respiring or normal pressure atmosphere, Sauerbruch, by varying the negative pressure, as required, has been able to conduct intrathoracic operations with almost the same confidence as in abdominal surgery. In the Meyer cabinet differential pressure allows the surgeon to use positive, negative, or combinations of both pressures as needed. The great distinction between the cabinet control of pneumothorax and intratracheal insufflation is that in the former autorespiration is depended on to conserve life, and already overtaxed and weakened nerve centers are called upon to formulate respiratory impulses, while during intratracheal insufflation these centers can be made to remain passive, thereby adding a determining factor between success and failure. Moreover, in some operative procedures those muscles which participate in respiration are rendered inactive, thereby making the use of intratracheal insufflation all the more imperative. This demand is accentuated whenever during the course of any intrathoracic procedure dislocation of the posterior lobes of the lungs inhibits the usual respiratory movements.

Respiratory movements are not only concerned in the aeration of the lungs, but also contribute a factor essential to the normal maintenance of the pulmonary circulation and of considerable importance to that of the systemic. Thus the pulmonary circulation may be regarded as of double function—the ventricular, impelling the blood onward with rapid pulsations of the cardiac rhythm, while the lungs contribute the slower but more voluminous impulses of the respiratory cycle. (Davies.)

Hence it is that during intratracheal insufflation Meltzer has found it inadvisable to use a pressure which altogether suspends respiratory movements, resulting in apnea and CO_2 asphyxia, and suggests that, in so far as it is possible or necessary, the lungs be periodically deflated five or six times to secure not only a more satisfactory diffusion of the air and anesthetic in the smaller bronchi and alveoli, but also to eliminate CO_2 accumulation, and further to preserve the stimulus of respiratory movements upon the pulmonary and

systemic circulations. In cases of open pneumothorax in which the respiratory mechanism is not paralyzed, spontaneous respirations offer the required aid to continuous intratracheal insufflation.

However, it is always advisable to arrange for occasional interruptions of the continuous insufflation, especially in operations in which the thorax has to be laid wide open and the posterior and inferior portions of the lungs have to be dislocated, in which condition spontaneous respirations are of no avail. The occasional deflation of the lungs insures the continuance and efficiency of the pulmonary ventilation under all circumstances. It is essential, however, that this deflation be not allowed to result in a complete collapse of the lung, for reinflation under the circumstances may leave portions of the lung atelectatio.

Moreover, such deflation is valuable as a diagnostic factor in differentiating healthy from pathological lung tissue by the change of color and the presence or absence of proper distention. Again, partial deflation is useful in left-sided pneumothorax, particularly in suturing the wounds of the heart, under which circumstances hemorrhage from the heart wound, according to Friedrich, diminishes in proportion as the lungs are allowed to collapse.

The partial pneumothorax thus becomes the regulator of the hemorrhage and is allowed to persist until suture of the heart wound has been completed, after which the pericardium and pleura are closed with the lungs properly reinflated.

Extensive laboratory experiments, which have been verified by post-operative results in the human subject, prove conclusively that so far as respiratory complications are concerned intratracheal insufflation is an innocuous procedure even in the presence of the lobar pneumonia. Also, it has been found in practice that the recurrent air-stream through the trachea precludes the possibility of aspirating vomited material or hemorrhage from the pharynx.

Physiologically, the intrinsic value of intratracheal insufflation is exemplified not only in the original work of Fell, but also in the laboratory experiments of

Shaklee and Githens on the treatment of strychnine poisoning, in which, although the very centers of respiration were paralyzed, intratracheal insufflation reached the climax of its usefulness as a measure of resuscitation and the conservation of life.

Meltzer has also found that anesthesia by intratracheal insufflation is far superior in many respects to the usual methods of administering ether. The anesthesia is much safer, far more readily controlled; less of the anesthetic agent is used, patients go under and come out more rapidly, and an efficient method of artificial respiration is immediately at hand to take care of untoward complications.

In recent studies on the influence of intratracheal insufflation on blood pressure and respiration, Meltzer and Githens found that a manometric pressure of from 30 to 40 mm. and a percentage of ether just sufficient to complete anesthesia, from 50 to 75 per cent. were innocuous, but that an increase of pressure and the percentage of ether for any appreciable length of time would result in an undulating fall of blood pressure, a slowly and diminished excursion of respiratory movements, with final cessation of breathing, although the heart continued to beat.

Resuscitation was possible in animals within twenty minutes by the insufflation of pure air. From the experiments it appeared that an overdose of ether first paralyzed the functions of the medulla, and then much later the functions of the heart. Hence the caution in administering intratracheal insufflation to reduce the ethery percentage in ratio to the shallowness and diminished rate of respiration.

Untoward respiratory and associated cardiac complications may also result from operative manipulation of the vagi and their branches, and the resulting false apnea may be controlled by the hypodermic use of atropin.

An increase of pressure, accomplished either by means of the air current or indirectly by momentary pressure on the larynx, is valuable not only in gauging the proper distention of the lung, but also in obviating cyanosis and in overcoming the resistance of neurotic

individuals to the anesthetic effects of the ether. All investigators have found it expedient to add a tank of oxygen to their armamentarium for intratracheal insufflation. Under certain circumstances a persistent cyanosis will develop, which nothing short of oxygenation will control.

While Brauer uses the Roth-Drager, and Davies the Alcock regulating chloroform apparatus in conjunction with mechanical respiration for purposes of pulmonary anesthesia, ether seems to be a far safer agent for routine narcosis by this method.

As early as 1827, Portal produced an artificial pneumothorax without thoracotomy by the injection of sulphuretted hydrogen gas into the thoracic cavity to place the lung at rest when affected with tuberculosis. Holmgren pursued the same principle of treatment for unilateral pulmonary tuberculosis even in cases in which adhesions between the visceral and parietal pleuræ contraindicated its use. Hamman, of Johns Hopkins, is now utilizing a similar technique with nitrogen gas. In the presence of adhesions, the preliminary injection of saline solution to collapse the lung is advisable before injecting the gas to produce the therapeutic pneumothorax.

Perforation of the thoracic wall does not always result in pneumothorax, unless the opening is larger in diameter than that of the glottis, or is valve-like in character as in oblique puncture of wounds. As a rule, pneumothorax will disappear when the opening in the chest wall has been closed by the adjacent integumentary structures. These two facts have enabled surgeons, by means of tubes under water and the use of rubber tissue dressings, to allow for post-operative drainage of the thorax without artificial control of pneumothorax.

Technique of Intratracheal Insufflation Anesthesia.—Apparatus for intratracheal insufflation anesthesia has multiplied rapidly since the popularization of the method by Elsberg. However, all apparatus is similar in certain essentials. The source of air current may be provided by foot bellows, hand-driven or electrically-driven pumps, and tanks of compressed air. The

air-current may pass directly into the ether container, or, as is more advisable, is stored in a low-pressure tank or gasometer, from which it passes into a Wolf bottle, to be heated and moistened, and thence by regulating valve, either directly into, or only partially through the ether container, thereby providing for aeration pure and simple or insufflation with varying percentages of ether.

Also a source of oxygenation is an expedient adjunct. The tube from the apparatus connects with a mercury manometer and thence to the intubation tube.

Davies, adopting Kuhn's idea of a double intubation tube, uses a manometer to gauge the inlet and outlet air pressures.

All experimenters have concluded that for the Meltzer-Auer technique a silk-woven catheter 30 cm. long and of a diameter one-half that of the glottis, usually from 22 to 26 of the French scale, serves as the best intubation tube. It should have an opening similar to the rectal tube at the tracheal end, should be absolutely smooth and semi-rigid to prevent it from being expelled by coughing or from being compressed while in position.

Its introduction is best accomplished after the preliminary introduction of narcosis by ethyl chloride-ether or nitrous oxide-oxygen-ether anesthesia.

Intubation is greatly facilitated by means of either the Jackson direct laryngoscope, Fischer's modification of Hayes' instrument, or the introducer devised by Cotton. After the patient has been deeply narcotized, the mouth is opened wide and so held by a gag. The head is well brought forward and the tongue pulled forward by an assistant until the opening of the larynx is brought into view. The metal guide is introduced into the opening and the intubation tube is gently pushed onward until it is seen to pass over the epiglottis into the larynx, after which the metal guide is withdrawn and the tube is pushed further into the trachea until it meets an obstruction, which is either the wall of the right bronchus or the bifurcation of the trachea. It is then withdrawn an

inch and is anchored in position to special mouth gags provided for the purpose.

The distance from the incisors to the bifurcation of the trachea is from nine to ten inches in the infant, twelve in a child, and about seventeen inches in the adult. The glottis in the adult is one-half the distance between the incisors and the bifurcation of the trachea, and Elsberg suggests making the intubation catheter accordingly to insure greater accuracy in adjusting its location.

One-eighth to one-fourth grain of morphine hypodermically ten minutes before the administration of ether to reduce the irritability of the larynx; or from twenty minutes to half an hour previously when preliminary anesthesia by ether is not resorted to. The induction of narcosis by intratracheal insufflation produces spasmodic coughing while the patient remains conscious.

With the intubation tube introduced to the correct position, air may be heard rushing through the catheter. Spasm of the larynx may now occur for a few moments, but is of no consequence. At this juncture the tube from the apparatus is connected to the catheter with the pressure gauge of the manometer controlling the air supply at 20 mm. and the ether percentage at 50. If the lungs are not kept properly distended by a pressure of from 10 to 20 mm. Hg, the intratracheal tube is either out of position in the right bronchus or is too small and is allowing too much air to escape by way of the trachea. In the first instance, the tube must be retracted, and in the second either a larger sized tube must be introduced or else slight compression of the trachea around the tube at the jugulum causes CO_2 accumulation and cyanosis.

Complete muscular relaxation is usually obtained with from 50 to 75 per cent. of ether, and during the course of narcosis the breathing is quiet, respirations are reduced by one-third, the face remains pink, while the veins of the forehead become prominent; the pulse usually remains full, bounding and regular, the pupils do not dilate, and frequently the corneal reflex is active, so much so that the condition of the patient is

rather one of analgesia than anesthesia. Reaction from the anesthesia is so rapid that care must be exercised to keep up etherization throughout the entire operation. The depth of narcosis is controlled by increasing the air pressure and the percentage of ether, while at the same time avoiding a condition of apnea, which supervenes at pressures of from 30 to 40 mm. Cyanosis and the accumulation of CO_2 during the operative procedure are controlled by periodic deflation and occasional oxygenation with air. Pure oxygen is dangerous on account of its toxicity when its tension becomes too great, and it is too freely absorbed by the circulation.

At the close of anesthesia, ether is turned off, and pure air, or a combination of air and oxygen, is insufflated under slightly increased pressure to blow out the ether from the trachea and alveoli. Patients come out from under the influence of pulmonary anesthesia by this method almost as soon as the insufflation is discontinued and the tracheal tube removed. Apnea is present for a few moments after the removal of the intubation tube, but regular breathing is then rapidly re-established. Post-anesthetic vomiting, headache, dyspnea and cardiac complications are of rare occurrence. Post-operative pneumonia, interstitial emphysema and pleural effusions have followed intrathoracic operations done under both cabinet and intratracheal insufflation methods and the determining etiological factor in the complication has not been readily determined. However, caution must be directed to a technical mishap which may occur, and that is an accidental injection of fluid ether into the lungs. Fischer cites a case in his own experience in which death resulted from this contretemps and the mishap has occurred in laboratory experiments. Only apparatus should be used which mechanically precludes the possibility of such an occurrence.

Again, post-operatively, it may become necessary to use insufflation without anesthesia to control shock, restoring respiration and circulation, and to prevent effusions. Under such circumstances the *Fell* in saving life under the most dis-

heartening conditions must be remembered, and the method pursued to its limits.

Aside from its value purely as a resuscitative measure in asphyxia, drowning, poisoning from drugs and anesthetics, the convulsive stage of rabies and tetanus, impaired respiratory function in certain diseases, it must also be remembered that intratracheal insufflation as a method of anesthesia is a very desirable adjunct to the surgery of the head and neck, and especially for operations on the spine when the patient must be placed flat on the stomach during the course of operative procedure.

While etherization in association with intratracheal insufflation appears to be the safest form of anesthesia for intrathoracic operations, Boothby, after using the nitrous oxide-oxygen-ether technique, has been favorably impressed with the latter method, and Willy Meyer also suggests that the innocuousness of nitrous oxide may play an important role in conserving patients under thoracotomy the additional shock of a poisonous anesthetic agent.

From THE LANCET-CLINIC, July 29, 1911.

THE THORAX.*

BY B. MERRILL RICKETTS, M.D.,
CINCINNATI.

THE subjects for consideration (surgery of thorax and its viscera) are probably first in importance in modern surgery, because of their vital and inaccessible characteristics, frequent injury and disease, and because they have been the last of the organs of the trunk to be subjected to the hand of the surgeon. Especially is this true of elective surgery—emergency surgery, more or less limited in its character, having been done from time immemorial. It will not be the province of our effort to deal profoundly with the embryological and minute anatomical structures of the thorax and its viscera; nor will their fundamental physiological aspects be considered. It will, however, be necessary to consider them somewhat grossly from time to time for better elucidation. To accomplish this, it is necessary to quote freely from various authors upon the subject of embryology. The middle portion of the embryo is divided into proto-vertebræ, which may be seen on the fifteenth day, but there are no traces of limbs on that day. A sharp bend in the middle of the back is perceptible, but this question has not been determined. About thirty-five pairs of the proto-vertebræ may be seen through the skin on this day. The sharp bend in the back opposite the yolk-sac disappears at the end of the twenty-first day, when the vertebræ become more distinct. The Wolffian ridges having made their appearance on the twentieth day, two vertebræ are especially distinct at this time, one opposite the posterior end of the heart and one opposite the allantoic stalk, respectively, and they rep-

*Lecture delivered to the students of the American Medical College, St. Louis, Mo., November 11, 1911.

resent the rudiments of the upper and lower extremities.

On the twenty-seventh day the back becomes straighter, and the proto-vertebræ are so well defined that the eight cervical, twelve thoracic, five lumbar, five sacral and five caudal veterbræ with the tail, may be readily distinguished. The roof of the attachment of the arm may be seen extending from the fifth cervical to the second thoracic vertebra. The Wolffian ridge connecting the arm and leg of each side is still present, but not well defined. The back becomes straighter, and the bony elements begin to give the body shape about the forty-second day. The body is formed by the sixtieth day, so that it has assumed human form. The sixth month finds the sternum well developed and becoming ossified.

The thorax is constant throughout animal and insect life, and its comparative study is therefore exceedingly interesting. The same principles more or less obtain with all, especially fish, reptiles, birds and mammals, but it is the thorax of man to which attention will be directed. The best-developed side of the thorax is that which corresponds to the hand which is most active.

The hard structures entering into its composition vary greatly, as do also their shape and consistency. When mature it is pear-shaped, and bounded above by the soft structures of the neck, behind by the vertebræ and ribs, at the sides by the ribs, in front by the ribs and sternum and below by the diaphragm.

It is one of the first parts of the body recognized in fetal life, being noticeable as early as the twenty-first day. Of its hard structures in man, the cartilages constitute about 12 per cent., the vertebræ between 60 and 70 per cent., and the ribs about 20 per cent.

Comparison of the thoraces of mammals more closely resembling that of man is necessary. In many of the vertebrates there is no partition wall separating the thoracic from the abdominal visecra; but when those more highly organized are approached, the structures known as the diaphragm will be found, however, often very imperfectly developed.

The thorax surrounds the organs of circulation and respiration with their sac, pericardium and pleuræ, and through it in all animals pass the pneumogastric nerve, the esophagus, ductus thoracicus, the large blood vessels supplying the upper and lower extremities, thymus and bronchial glands, and mediastinal, pleural and pericardial spaces. The soft structures enveloping the thorax, fasciæ, fat and skin, with their nerves, blood and lymphatic vessels are also to be reckoned as surgical entities.

Any variation of one or more of these structures from normal is due to injury or one or more of the diseases herein to be enumerated. However, the soft structures will not be considered in this work, except so far as they directly concern thoracic surgery. Many diseases, such as pneumonitis, pleuritis, pericarditis, mediastinitis, tuberculosis, and some of those due to mycoses and parasites are not necessarily surgical, but they may become so at any time during their existence.

Indications.—Injuries, deformity, carcinoma, sarcoma, dermoid cyst, fibroma, lymphoma, lymphadenoma, lipoma, gummata, chondroma, tuberculosis, hydatid cyst, hemorrhage, hematoma, pus, serum, emphysema, caries, osteomyelitis, fistulæ and cysts.

Thoracic Surgery, as herein indicated, pertains to the bony and cartilaginous structures and the various tissues and organs which they surround.

Extra-thoracic surgery constitutes all work external to the pluræ, *i. e.*, the cutaneous structures, mammary glands and scapulæ. The clavicles might with propriety be included, for they are within the boundaries of the thorax, upon and attached to it.

Intra-thoracic surgery is that which pertains to the tissues contained within the thorax, but many conditions demand both extra and intra-thoracic surgery.

Injuries of the thorax and its viscera are so frequent and important that this work would not be complete without the consideration of those which do not necessitate surgical operation. The hard structures of the chest and its viscera may be injured to such a degree, with or without laceration of its overlying

integumentary structures, that surgical attention without operative measures, other than some form of dressing, may be necessary, because they may at any time become surgical. Any condition that may become surgical during its repair should as a rule be under the surveillance of a surgeon from its earliest inception. He should share the responsibility with the attending physician, who may not be surgically inclined, because the rights and advantages of the afflicted can then be better conserved.

Deformity of the thorax may be the result of irregular embryological development, disease or injury before birth; or it may be due to trauma during passage through the pelvic opening, or after injury or disease of one or more of the hard structures entering into its formation. Tuberculosis of the vertebræ and improper nourishment (rachitis) are the two most common causes.

THORECTOMY (PARTIAL).

Thorectomy, partial, constitutes not only an opening but a removal of some of the structures of the thorax. The indications are foreign bodies, neoplasms, caries, cysts, abscesses, cardiolysis, pneumolysis and fistulæ. With foreign bodies it may be necessary to remove one or more ribs or cartilages and to replace a part or all of them, but if a neoplasm is in the mediastinal space, a partial, never a complete, thorectomy is necessary. Complete would mean the removal of all the bony structures of the thorax. If the neoplasm be upon the vertebræ or the diaphragm, it may be necessary to remove a part of one or more ribs, but never the first rib.

Resection of ribs and pleuræ en masse is done when the hard structures are not to be replaced, when a larger opening than an intercostal space is desired, and when it is to be maintained indefinitely.

Subperiosteal resection of ribs or cartilages may be done for injury, disease, exploration or for intrathoracic operations of any character. Caries of one or more ribs or cartilages would necessitate their removal and all additional diseased soft tissues.

With echinococci, abscesses or blood cysts of any character it may be necessary to have perfect drainage through an opening large enough to introduce gauze packing, and any pathologic condition due to disease or injury might necessitate removal of one or more ribs, which is difficult to do without opening the pleura.

Cardiolysis and pneumolysis require the removal of a part of the bony and cartilaginous structures. Thickened pleuræ which contracts the lung is then removed. An abscess cavity in the lung will collapse, and in that way become obliterated. So it is that the heart in cases of pericarditis with effusion, and where there are pericardial adhesions interfering with cardiac expansion, the structures are removed from over the heart, that it may have more expansion and thereby better perform its functions.

INDICATIONS FOR THORECTOMY—INJURIES, FOREIGN BODIES, NEOPLASMS, CYSTS, ABSCESS, FISTULAE, EMPHYSEMA AND OTHER INTRA-THORACIC CONDITIONS.

Injuries of any of the structures of the thorax or tissues within it may necessitate the removal of some of the bony or cartilaginous walls.

Foreign bodies may be mineral, vegetable or animal in character, and vary in size, shape and number. They may form within (broncholiths), enter from without or through the bronchus, and may be of recent origin or have been imbedded indefinitely within the soft or bony structures, with or without sinuses, varying in size, shape, number and location.

Neoplasms of any character often necessitate the removal of a part or all of one or more ribs or cartilages, or both, and when not infected, wounds for such purposes usually remain aseptic and require but little attention.

Caries of bone or cartilages, due to injury, tuberculosis, syphilis, osteomyelitis, malignancy or any of the acute infectious diseases, necessitates the removal of all diseased tissues. They are always infected, and any wound made for their removal remains so. There may be one or more foci limited to one or more ribs or carti-

lages and the time for repair may extend over several months, during which time multiple operations may be necessary. Wounds for all such conditions are complicated.

Cysts within or surrounding the bony chest vary in kind and degree, and they may be due to injury or pathologic organism, such as tuberculosis, osteomyelitis, syphilis or parasites, and contain blood, pus or serum from the pleural or pericardial cavities, usually infected, and when so become complicated.

Cardiolysis was first suggested by Brauer, 1902, and performed by Peterson for cardiac embarrassment due to fixation of the pericardium to its adjacent tissues.

Ernst Venus, in 1908, records seventeen such cases operated by a horseshoe flap, the base of which was over the third and fourth ribs with their cartilages removed. Sometimes the third, fourth, fifth, sixth and seventh ribs and their cartilages are removed when adhesions are extensive. The periosteum of all should be left without opening into the pericardial or pleural cavities. Such wounds should not be infected, and when not so are easily cared for without drainage.

Abscess, Pneumolysis.—Several or all the ribs, except the first, with their cartilages on one side are removed without their periosteum, and without opening the pleura or pericardium. When collapse of the chest wall is desired in tuberculosis or other forms of pulmonary abscess, and when rapidly done without the above complications, it is a simple and effective means of giving relief, but such wounds are always complicated.

Fistulæ are due to many causes, of many varieties and degree. They may originate in the thoracic wall; the pleural or pericardial cavities, cardiac wall, within the lung, bronchus, esophagus or mediastinal space, and may necessitate removal of ribs or cartilages, or they may be treated with bismuth paste injected through their tract, but they are always necessarily complicated. (See Beck on bismuth paste, p. —, 1910.)

The after-care of thorectomies, especially if the pleural cavity is opened, is more complicated than either uncomplicated fractures or thoracotomies. If

the pleura has not been penetrated the treatment of thoracotomies obtains (see thoracotomy), but if the pleural cavity has been opened, the dressings must be with reference to preventing pleural and lung infection, and keeping the pleural opening closed that the lung may continue to expand and thereby functionate.

Emphysema of the lung, especially of the alveolar type, should be relieved by dividing several ribs in their cartilaginous area, and the removal of a segment of each rib extending from and including the second to the seventh. These segments may be from one-half to one inch in length, and in osteo-cartilaginous boundary, and should include the retro-costal periosteum. If this does not improve thoracic mobility there is nothing more to be done. Friedrich, however, recommends this procedure in all forms of emphysema, stating that it has yielded brilliant results. This method was first advocated and practised by Freund, who continues to be its enthusiastic supporter.

Dressings, somewhat voluminous, should be frequently changed, keeping a pad of such material firmly applied to the opening during the entire process of changing. If the opening is high upon the chest a secondary opening should be made low upon the side (if the body is to remain recumbent) that gravity drainage may be assured with or without one or more of the drainage materials. Drainage may in this way be temporary or permanent, periodical or constant, as the exigencies of the case may require. As a rule under these circumstances irrigation of the pleural cavity should not be done, especially not with medicated solution. If at any time irrigation should be necessary, the return flow should equal the inflow, and the irrigation medium should be sterilized water heated to the degree of tolerance. Dressings should be changed whenever they are sufficiently soiled, and with every aseptic precaution until pleural adhesions about the openings are assured and the wound sufficiently closed to justify their discontinuance.

SOFT STRUCTURES, RIBS AND CARTILAGES, FRACTURE.

Soft structures of the neck seldom concern injuries and operations upon the thorax and its viscera except

punctures by knife or gunshot, so that but little will be said concerning them. (See Lane, "Surgery of the Neck," pp. 903-1166, 1898.)

The sternum is composed of dense cartilage, and extends from the diaphragm to the neck in the anterior median line. It varies in thickness and width, but normally it is about two and one-half inches wide. It consists of three pieces, the manubrium extending downward to a point opposite the second rib; the gladiolus extending to the seventh rib, which is its last articulation, and the zyphoid cartilage constituting its extreme lower portion. It constitutes about 10 per cent. of the hard structures of the thorax, and is frequently subject to injury and disease. The zyphoid portion is usually perforated and it may be bifid. Congenital defects, such as cleft, are common, usually slight, but sometimes cardiac pulsation may be distinctly observed through them.

Costal cartilages constitute about 10 per cent. of the chest wall, and they are very commonly subjected to resection and cartilaginous flaps when injured or diseased.

Periosteum covers all the bony tissues entering into the formation of the thorax with the exception of the cartilaginous structures, which are covered with pericondrium, which serves the same purpose. It is always concerned in injuries and operations upon the chest and its viscera.

Twenty-four ribs and their corresponding vertebræ constitute the greater portion of the chest wall. The former are more frequently considered surgically in injury and disease of the thorax and its viscera.

FRACTURES.—SIMPLE, COMPOUND, COMMINUTED, COMPOUND COMMINUTED.

The ribs may be fractured or they may be subject to any of the diseases necessitating surgical interference. Fractures may be simple, compound, comminuted or compound comminuted. Pathological conditions may be malignant or non-malignant, neoplasms, osteomyelitis, tuberculosis, syphilis and osteomata Any of these may attack the cartilages, ribs or verte-

bræ, and while the cartilages and bony structures are subject to the same injuries and diseases, either may take on active inflammation and result in carious degeneration, which may necessitate the removal of a part or all of any one or both. More than one hundred cases have been reported due to the bacillus typhosus. The periosteum covering the entire bony structures of the chest varies in thickness, but it is practically of the same organization and regenerating purposes.

Neoplasms, osteomata, carcinomata or echinococci may be present; they may be checked in their course, without serious consequences, destroy a part or all of the bone or cord, or extend directly or indirectly into other tissue or organs.

Cysts may contain blood or pus, due to bacteria or parasites.

Abscesses are usually due to tuberculosis, but they may be due to syphilis, injuries or infarcts, producing the same symptoms.

Fractures of the ribs and cartilages are due to many causes, usually traumatic, but they may be due to osteomyelitis, syphilis, neoplasms, or muscular contraction, known as spontaneous fracture. Usually the point of fracture is in the median or lateral line, or separation from the costal cartilages may ensue.

Fracture of ribs, when due to direct violence, are usually driven inward through the pleura and often into the lung. This is the class of fractures which most frequently require direct surgical relief by excision. The fractured ends may be transverse, oblique or spicular, the latter two being most serious because of their sharpness.

The second form of fracture is due to indirect violence, as when the force is applied distant to the point of fracture, such as a crush. With these the ends are usually directed outward, which lessens the possibility of puncturing the lung.

Simple fractures are best treated by rest, depending upon the degree and number of ribs involved, and location of the fracture. The time required for repair depends upon the age and condition of the patient,

usually fifteen to twenty days in the young with good health, while forty, sixty or ninety days may be required, or union may not occur at all with those of advanced age or in ill health. If one rib is fractured it is supported by the ribs on either side, as with the fracture of a paling in a fence; the paling is not easily displaced, because the other palings hold it in position, but when more than one rib is fractured, there is usually displacement. While the treatment for the fracture of a single rib is rest, sometimes the patient may not even remain in a recumbent position, or may continue to perform regular duties. Adhesive plaster is usually of but little benefit on the obese, because it will become merely a narrow band. The most desirable way to support the entire chest from the diaphragm to the axillary space is with a bandage snugly adjusted with safety pins placed anteriorly. The patient can then resort to abdominal breathing by increasing the number of respirations to twenty or thirty a minute. When this is done the amount of oxygen is increased, permitting the same amount to be inhaled that would have been with fifteen normal respirations. With these few instructions the treatment of fracture of one rib is usually simple if the lung is not involved; when so the treatment will be more complicated. If the ribs are separated from their cartilages union is slower and less likely than when the rib alone is fractured.

The time for cartilaginous union is sometimes several months, but injections of alcohol in or about the point of separation sometimes creates enough inflammation to hasten union. If, however, they do not unite with any of these methods, they may be brought together and retained with wire. This may be done subcutaneously by passing a long needle around the rib, which will hold the fragments in position until they do unite. This is done on the same principle that wings of birds are made fast to prevent flying. Formerly the distal joint of one wing was amputated, but now the outer extremity of one wing is flexed and fastened with wire until the joint becomes ankylosed, so that uniform action of the wings is pre-

vented. This is done without pain or disfigurement, and flight is made impossible.

Fractures of the sternum are due to direct or indirect blows, and they may or may not be displaced. In either event serious trouble may ensue, especially when the upper portion is displaced, for then the trachea may be compressed, because it is directly beneath this portion. The heart may also be injured by such a displacement, because of its close proximity; depressed fragments should be elevated; if necessary removed in their entirety, and all bleeding vessels ligated or compressed by forceps or pledgets.

Simple fractures, involving one or more ribs or cartilages or both, without dislocation, require little if any surgical care. One broad or several narrow strips of adhesive plaster partially or completely encircling the thorax to fix fractured ends in apposition is too frequently practised, especially in the obese. Broad bandages of cotton, linen, wool or silk fabric give much benefit. The plaster of Paris jacket is practically useless. Indeed, there is but little for the surgeon to do in the absence of complications. However, much instruction can be given that will, if complied with, be of more or less benefit. Shallow abdominal breathing, increased in frequency, will prevent expansion which separates the fragments, and causing pain. If the chest is made rigid while the body is recumbent, the separation of the fragments is less frequent. If, however, the pain is severe, it should be relieved with a narcotic. Should the fragments fail to unite at the expiration of four months, alcohol or fluid extract of quercus albi should be injected into the soft tissues immediately surrounding them. At the expiration of another ninety days, if they have not united, they should be directly fixed with wire by the subcutaneous or open method.

Compound fractures of the ribs or cartilages are difficult to care for under the most favorable circumstances. The results are sometimes very unsatisfactory, because of the various complications which frequently arise. With such a condition they should be

cared for upon the principles designed for the purpose and when not complicated their care is simple.

Comminuted fractures are not infrequent, and at times are of a very serious nature, especially if the pleura is lacerated, or the lung, pericardium or heart perforated, blood being usually retained within the pleural or pericardial cavities. It then becomes necessary to convert them into compound comminuted fractures that the blood may be removed, and the care of a complicated wound instituted.

Compound Comminuted Fractures are the most difficult of all to treat, because of the extensive trauma and many complications that may arise. It may sometimes become necessary to remove fragments of bone before the first dressing is applied. If not then, this may become necessary at any subsequent time before repair is complete, but all such wounds must be treated as complicated. Fractures are the most common condition requiring treatment, so that the after-care necessitates recumbent rest alone or with some kind of support to prevent motion of the fragments. Some form of bandage may be made to encircle the entire chest. A snugly-fitting muslin bandage or jacket, extending from the twelfth dorsal to the axillary space will usually be sufficient. Such a support may be readjusted with safety pins at any time without changing the position of the body.

Adhesive plaster may also be employed for this purpose, especially if broad strips are applied to the entire circumference of the body, and made to extend from the twelfth dorsal to the axillary spaces. The latter cannot be so well applied in the obese, nor can they be readjusted so easily or with as much comfort as the muslin bandage. The foregoing treatment is especially applicable to such injuries as are not complicated with laceration of the overlying soft structures

This treatment may, however, be employed with the existence of laceration of the soft parts, if the bandages can be applied in such a way as not to come in contact with them, but it may be necessary to provide for and maintain drainage indefinitely, independ-

ently of the circular bandages. It is then very difficult to keep the dressings clean, and for that reason the possibilities of infection are greater with adhesive plaster.

Dressings should be changed frequently under aseptic precautions, with or without wound infection. The time necessary for the bandages to remain around the body depends upon the age of the patient—fifteen to twenty days for children and twenty to thirty-five days for adults.

The prevention of violent exercise, such as changing position of the body, coughing, sneezing and vomiting is more necessary in the after-care of surgical operations upon the thorax and its viscera than any other part of the body, and because of their mechanical effects should be avoided by any means, employing narcotics or sedatives if necessary. Fractured ribs or cartilages may be separated, severe pain produced, or a ruptured, lacerated or incised wound of the diaphragm, or any of the intrathoracic viscera reopened after it has been closed by suture..

THORACOTOMY.

Thoracotomy may involve one or more of the cartilages or ribs or the two combined; sometimes they are extensively concerned in osteo-cartilaginous flaps for exploration or operations upon the thoracic viscera.

The prognosis of perforating wounds of the right is more favorable than similar injuries of the left thorax. (Dorrance.)

Penetrating wounds, complicated with hemothorax or pneumothorax, demand thoracotomy.

Trap-door methods are preferable, but when a wound already exists they may not be advisable. They may be done more rapidly, are less complicated, and the section of the ribs can be restored to unite and continue their function. A transverse incision is made, extending from the anterior median line backward as far as necessary through the overlying soft structures, including the periosteum. A transverse incision six inches in length will expose only two or

three ribs, but upon extending the incision backward to within four inches of the spinous process of the vertebræ as many as five ribs may be exposed. Such an incision (transverse to the body) divides the ribs obliquely, while a perpendicular incision severs them transversely. This is of importance, because coaptation of oblique is more perfect than transverse fractures.

In the absence of infection all bony or cartilaginous portions of the flap may be returned to their normal position with reasonable assurance that they will be preserved. Thirty-day chromacized catgut or wire may be used to secure the ends of the bones in perfect apposition.

The indications for it are the presence of blood, pus or serum within, and lacerations and puncture of the thorax. There may be a puncture of the internal mammary or intercostal artery, necessitating a large opening in the thoracic cavity to check hemorrhage, it being impossible to explore through the intercostal spaces, small openings through this space being made only for drainage. Division of one or more ribs may be done within thirty or forty seconds, it not being necessary to ligate the intercostal vessels when doing so, because crushing with forceps will prevent hemorrhage. Hemorrhage from the internal mammary is easily controlled by forceps or ligature. The chest is opened for pus as in empyema, serum, exploration, neoplasms, injuries, lacerations of the pleura or injuries to the lungs, pericardium or heart, or other intra-thoracic tissues. It is also opened for punctures, large or small, the latter as a rule being more serious. No part of the thorax is removed in thoracotomy, because incisions into the osseous and cartilaginous structures are for the osteoplastic flaps, with or without their periosteum and subjacent soft tissues. The dangers are increased with the degree of tissue disturbance and with opening the pleural, mediastinal or pericardial cavities. It may be penetrating or non-penetrating, and vary in extent and location.

Exploration with the trocar, excision or osteoplastic flap sometimes results in a wound of great magnitude, so that there is no viscera or tissue that cannot be ex-

plored with a reasonable degree of safety, especially when pleural adhesions exist. Existing infection need not preclude such a possibility, though it may, however, complicate the after treatment.

INDICATIONS FOR THORACOTOMY.—BLOOD, PUS, SERUM, EXPLORATION, LACERATION, PUNCTURE, NEOPLASMS.

Blood in the pleural cavity may be a frequent cause for excision of ribs or cartilages, that it may be removed. It may be from any of the thoracic vessels and small in amount, which may become absorbed; therefore, small amounts without infection, should not be interfered with. If the amount is large and seriously presses upon the heart or lungs or both, and continues to do so, the chest should be opened and all of the clots and fluid removed, but the wound then becomes complicated.

Pus is a frequent cause for the removal of one or more ribs and cartilages, and it should be removed regardless of the amount or character, whether in the pericardial or pleural cavity or within the lung, cardiac wall or soft structures of the chest, but such wounds are complicated, as they are necessarily infected.

Serum within the pleural and pericardial cavities in large quantities often necessitates removal of one or more ribs or cartilages; however, with a few exceptions it may not be necessary, but when this fails, extensive thoracotomy should be resorted to. The dangers of infection are much greater with open wounds, and when they exist greater precautions are necessary to prevent mixed infection. It is this class in particular which demands the greatest consideration and skill in the after treatment.

Lacerations may occur without fracture of ribs or cartilages, and are less inclined to bleed than wounds caused by a knife. They are irregular in shape and vary in length, depth and location. Considerable degree of laceration may exist without much if any trauma to the bony cartilaginous tissues, and the intercostal tissues alone may be destroyed without

much bleeding. They may also be lacerated without laceration of soft tissues directly overlying them, and when not complicated need not necessitate much after-care.

Punctures may be penetrating or non-penetrating, and involve the soft, bony or cartilaginous structures. They are more serious when they extend into the pleural, pericardial or mediastinal cavities or penetrate the viscera. With either one or all of these conditions drainage may become necessary, but they then immediately become complicated.

Neoplasms of many kinds may involve the soft or hard structures or both, and they may be malignant or non-malignant, necessitating radical measures for their cure. If confined to the overlying soft structures, their removal may be comparatively easy, but when the ribs or cartilages are involved the work is more complicated because it may be necessary to enter one or more of the thoracic cavities.

There are two forms of treatment for thoracotomy —one without infection or drainage, and the other with infection or drainage. The first is a simple wound in the beginning with sutures, but it may become infected early or late in the reparative process. If not infected at any time the treatment is simple, because the primary dressing need not be disturbed until the seventh or eight day, when the sutures should be removed. The dressings should be kept in position by means of a muslin jacket adjusted to the entire length and circumference of the thorax with pins, or adhesive strips may be substituted for the muslin jacket. The second form of treatment is more important, because it concerns a more serious condition. The blood or serous drainage at the time of the application of the primary dressing may continue aseptic throughout recovery, in which daily or semi-daily dressings may be necessary, depending upon the amount of flow. The drainage may be only temporary, with or without tape, gauze or tube, or it may be permanent. Seldom is the latter necessary, as any kind of drainage of this character may be discarded any time during convalescence, but if infec-

tion occurs the wound must be treated as though primarily infected.

Especially is the after-care more serious in primary infections, because the first dressings must be with reference to drainage. Strips of gauze, tape or rubber tube are necessary to keep the wound open, and the dressings should be voluminous and changed probably every few hours.

Irrigation with warm salt or soda water (one-half ounce of either to a quart of water) or some disinfectant should be generously applied as necessity demands until the wound becomes closed. The dressings for such cases are best kept in place by a muslin jacket with pins adjusted in the anterior median line.

INDICATIONS FOR LAMINECTOMY.—FRACTURES, DISLOCATIONS, CARIES, FOREIGN BODIES, NEOPLASMS, CYSTS, FISTULAE, DEFORMITY.

Vertebræ, twelve in number, form the posterior median wall of the thorax. They are frequently concerned in surgery of the thorax and its viscera, and when so are a most serious complication in after-care and final termination.

Fracture.—Any part of one or more vertebræ may be injured to such a degree that surgical measures for its relief may be necessary. Blood vessels may be lacerated, pneumogastric nerves torn or compressed, the esophagus, lymphatic duct or lung perforated, or infection with subsequent bone necrosis may result.

Dislocation may be without fracture, and there may be fracture without dislocation, or the two may be coexistent. They may be pathologic to such a degree as to necessitate surgical remedy, or be attacked without being diseased to expose the cord or foreign bodies within them. Displacement may be partial or complete, but always with more or less cord involvement. Surgical measures are especially indicated when pressure symptoms are present.

Caries.—Probably 95 per cent. of vertebral caries is due to tuberculosis of their bodies. The remaining portions of the segment remains unaffected, but its

spine projects backward as the result of collapse of the shell of the body, and thus produces kyphosis. The dorsal vertebræ are most frequently affected. Caries may also be due to syphilis or osteomyelitis, and involve a part or all of one or more verterbræ. Such wounds are always infected, and almost invariably demand surgical relief, by aspiration, open incision or fixation with mechanical devices.

Foreign bodies may enter one or more vertebræ and remain there or pass entirely through them or into the spinal canal, where they may rest. Surgical measures are not always indicated, seldom so, unless the foreign bodies or fragments of bone remain in the spinal canal, or bone necrosis results from infection, but pressure symptoms always require the removal of the foreign body or fragments of bone.

Neoplasms, malignant or non-malignant, may originate within or upon any one or more of the vertebræ, and progress to such a degree as to necessitate surgical means to relieve or eradicate them. Growths within the vertebral canal causing pressure symptoms should always be removed.

Cysts may be bacterial or parasitic in their origin, contain blood, pus or serum, and involve one or more vertebræ. Those containing blood or serum are not always infected, but may become so at any time. Aseptic or septic cysts should be evacuated by one or more of the recognized surgical methods, such as aspiration or incision.

Fistulæ may result from disease or injury to any one or more of the vertebræ. They are always infected, but may or may not necessitate surgical operations to obliterate them. When the result of caries they may pass backward, laterally, anteriorly or downward, seldom upward owing to gravitation, and they may occur at any place below their origin, usually through the psoas muscle.

Deformities are due to injury, disease or congenital defect, and may require surgical methods to correct them.

Laminectomy.—An incision is made in the median line over the spinous processes along each side of

the laminæ. The periosteum is elevated with a chisel, outward to the transverse processes. The laminæ and spinous processes may be divided with bone forceps or a saw, after which the dura mater, surrounded by fat and connective tissue, is exposed. Great care should be exercised to avoid injuring the cord or any of its lateral branches. While sensory nerves will reunite, injury of the anterior motor root results in permanent paralysis. Hemorrhage during this operative procedure can be controlled by pressure with gauze.

After-treatment of injuries to the thorax concerns traumatic conditions not necessarily requiring surgical operations. They may be confined to its bony or cartilaginous structures or both, and the vertebræ or ribs or both may alone be involved or they may be associated with the sternal or costal cartilages or the cartilages may be affected independently.

The Spine.—After-care of operations upon the spine is exceedingly difficult owing to the danger of infection resulting from bedsores (which may appear at any time) and urine and feces which escape involuntarily; also the secretions from the wound and occasionally the presence of cerebro-spinal fluid. Dressings should be replaced frequently if soiled. The position of the body changed twice daily and massaged with alcohol.

FROM THE LANCET-CLINIC, SEPTEMBER 23, 1911.

SURGERY OF THE PLEURA.

PLEUROTOMY, PLEURECTOMY, PLEURORRHAPHY.

BY B. MERRILL RICKETTS, PH.B., M.D.
CINCINNATI.

The pleuræ are extensions of the peritoneum, and their functions are the same, secreting and excreting, and performing all of its physiological functions.

Anatomy.—The parietal pleura covers the inner chest wall and the visceral pleura the lungs; by such an arrangement the cavities are formed independently of each other.

The cervical pleura is associated with the clavicles and sterno-mastoids, and are described by Dickey as follows: "The sterno-mastoids are each about 6 cm. (2½ inches) in breadth, measured along the upper border of the clavicle."

The *total breadth* from outer border to outer border is 13.5 cm., or 5¼ inches.

The brachial plexus and subclavian artery are seen externally, the isthmus, etc., in the middle line.

The subclavian and internal jugular veins; the subclavian, carotid and innominate arteries; the brachial plexus, the scaleni muscles, etc., are shown after the sterno-mastoid muscles and the depressors of the hyoid bone are removed.

A small part of the subclavian artery is removed from its groove on the anterior and inner aspects of the pleura. The vagus nerve and the anulus of Vieussens cross the first part of this artery in the position shown. The scalenus medius supports the pleura externally and behind. Here also is found the lower trunk of the brachial plexus. In a considerable number of cases the third part of the subclavian artery rests on the pleura as well as on the upper surface of the first rib. This is a point noted usually by sur-

gical writers, but not mentioned in anatomical descriptions of cases, the third part of the subclavian artery resting on the pleura internally.

The question how the cervical pleura is supported against the intra-thoracic pressure is of importance in considering the apical invasion of tuberculosis; as, if the first costal arch is raised, and the cervical pleura is not raised in at least a corresponding degree, the aëration of the apex will be defective. English text-books of anatomy give rather brief accounts of the supports of this important region. To quote Cunningham's text-book:

"The cervical pleura is strengthened and held in place by an aponeurotic expansion, first described by Sibson, which is spread over it, and is attached to the inner concave edge of the first costal arch. This fascia is derived from a small muscular slip which takes origin from the transverse process of the seventh cervical vertebra."

The Diagnosis of Pleuritic Effusions in Infancy.—Miller emphasizes the following points: Pleurisy with effusion is a common affection in infants under the age of two years. In the majority of cases it is purulent. Because of the disastrous and even fatal results of delay in or mistakes of diagnosis, it should be recognized early, so that prompt—that is, surgical—treatment may be instituted The diagnosis is often obscure, demanding in the highest degree carefulness, skill and experience. In arriving at a diagnosis the antecedent affections should be fully appreciated. Of these, pneumonia is by far the most common. The general symptoms, as well as the physical signs, should be carefully weighed and considered. Of these, the latter are the more distinctive. The most reliable signs, in the order of their importance, are (1) exploratory puncture, (2) dulness with a sense of resistance, and (3) displacement of the apex. The other physical signs, so valuable in differentiating effusions in the adult, are uncertain, variable and confusing, and cannot be relied on in infants. The recognition of localized collections of fluid is especially puzzling, and demands great skill and watchfulness and a frequent

resort to exploratory puncture or operation. The latter is safe, even when the lung is pierced, and particularly so when fluid is present. Notwithstanding the rare accidents that have followed this procedure, it should be employed to determine the character of the fluid, and, owing to the distressing results of unrecognized empyemas, it is imperatively demanded in all doubtful cases. The variability of the physical signs is a striking feature in infants and should always suggest an effusion.

The mediastinum oscillates toward the sound lung in empyema, and thus accounts for cyanosis and rapid respiration, both of which are overcome by differential pressure.

Air in an abscess becomes negative during inspiration, consequently the mediastinum and pericardium are deflected toward cavity of collapsed lung.

PLEUROTOMY.

The pleura may be injured or diseased so that surgical measures may be necessary, or it may become necessary to incise, remove or suture it in the course of dealing with purely intrathoracic conditions.

Pleurotomy applies to penetrating or non-penetrating wounds of the parietal or visceral pleura, whether they be intentional or accidental, incised or punctured. It may be for exploration; the removal of fluid, foreign bodies or neoplasms; the introduction of fluids or gas to remain, or surgical operations upon the thorax or any of its contents.

Pleurotomy in the form of "paracentesis" was mentioned by Van Ekuyck, 1738, and Wickham, 1773. These are among the earlier records upon this subject.

Porral, 1829, injected sulphuretted hydrogen into the pleural cavity to check hemorrhage. This is the very earliest record of gas being injected into the pleural cavity, and no doubt was the incentive for its subsequent use.

Thiriar, 1877, injected tincture of iodine for the treatment of purulent pleurisy in a child, and Vayla, 1883, used the thermo-cautery.

Hemopneumothorax.—Blood may escape into the pleural cavity from the pulmonary, intercostal, internal mammary, mediastinal or larger vessels, but if small in amount it may become absorbed, and therefore not necessitate any surgical interference. If the amount is great, it is usually necessary to remove it under aseptic precautions, and, being usually coagulated, a large opening will be necessary for drainage.

Pyopneumothorax.—Pus may form within the pleural cavity primarily, or it may enter from a pulmonary abscess due to any cause, or it may escape from the mediastinum. Blood or serum may become infected after it has entered the pleural cavity, from a wound for the removal of neoplasms, foreign bodies, necrosed bone or cartilages. In either event it is absolutely essential that perfect drainage be instituted with gauze, tape or rubber tubing. Convalescence is usually very slow, and the after-care considerable.

Hydropneumothorax.— Serous effusions of the pleura are of frequent occurrence, and due to inflammation of any of the thoracic viscera, especially the pleura on the right side. An enlarged heart may draw the vena cava downward, causing the vena azygos major to compress the right bronchus and thereby produce such a condition An enlarged right heart has also been a cause by pressing upward on the root of the right lung, and thereby pinching the azygos major vein as it curves over the right bronchus to enter the superior vena cava.

Compression of any of the blood or lymph channels will cause such effusions, which are usually on the side corresponding to the pressure. They are, however, more frequently upon the right side, and when so are usually due to dilatation of the right side of the heart.

Serum may form within the pleural cavity, or it may enter it from a pulmonary, bronchial or mediastinal cyst, or one within the thoracic wall. Its removal is usually done by trocar during several sittings, seldom requiring the removal of ribs or cartilages. The amount may vary, and if small may not require re-

moval by artificial means, because it may become absorbed. If removed by any method, and not followed by infection, the after-care is simple and convalescence usually short.

Echinococcic cysts seldom appear primarily in the pleura, but when present such cysts should be evacuated and the parasitic cysts destroyed.

The Spinal Sign of Sero-Fibrinous Pleurisy.— F. Ramond found the ilio-costal and longissimus dorsi muscles constantly enlarged on the side corresponding to the pleural lesion in 76 cases of primary pleurisy and in 18 out of 24 secondary cases. The muscles below the twelfth rib can be felt much larger and more elastic on this side than on the other, as the patient bendsforward or to the side, and the groove at the side of the spine is palpated. His communication on the subject was published in the *Bull. de la Soc. méd. des Hop.*, xxvii, 747, 1910.

The following report was made as late as May 12, 1864. It shows how little consideration was given to thoracentesis. It is entitled "Human Hybridity."

"An interesting discussion on thoracentesis has been for some time engaging the attention of the *Société médicale des Hôpitaux* of this city. Perforating the thorax is a very important operation, and it ought not to be advised but in real danger. As a general rule, it should be performed in every instance in which the attending symptoms are hazardous and cannot be removed by other means. This operation is always indicated where the action of the heart is much impeded by fluids collected in the cavity of the chest. Hitherto it has been supposed to be applicable to the evacuation of water or of pus only, and chiefly of the latter in the disease termed empyema. But surgeons are inclined to think that it is equally proper for the discharge of any other fluid, as for collection of water or purulent matter, such, for instance, as blood, and even air. Thoracentesis has often been resorted to, but only in extreme cases. This fact suffices to account for the unfavorable termination which has often attended it. When performed early, and under favorable circumstances, it is calculated to produce great relief, even if it should fail to remove the disease. There are, however, serious disadvantages to contend with, and which

render this operation far more serious than appears at first sight. The constant motion of the lungs favors the continual production of pus, which is discharged through the opening of the thorax. Another obstacle is an impossibility, in the actual state of the surgical art, of inducing that degree of inflammation known to be the most powerful means of uniting parts that have been divided by the formation of matter. So that, although in a few instances the quantity of matter gradually decreases, and the external opening contracts and heals, yet it is acknowledged that in a great proportion of those who have undergone the operation of thoracentesis for purulent collections in the chest, the discharge continues for a great length of time and not infrequently for life."

"Should the opening heal, matter being constantly formed collects again in such quantities as to produce a renewal of the symptoms of oppression, so much so indeed as to render another operation indispensable. The *Société médicale des Hôpitaux*, after discussing the *pros* and *cons* of this important sketch, seem to have arrived at the following conclusions: (1) The operation of thoracentesis is usually unsuccessful in chronic pleurisy. (2) There is urgent necessity of operating in cases of immanent asphyxia, excessive quantity of fluid causing the displacement of the viscera contained in the chest, and resistance of the purulent collection to ordinary treatment."

Punctures and incisions of the pleura may be done through the intercostal spaces, or after one or more ribs or cartilages have been removed subperiosteally, and the dangers are somewhat proportionate with the degree of surgical trauma. However, small punctures and incisions are sometimes more dangerous than those of greater magnitude, because of imperfect drainage when infected.

The most favorable points for aspirating the pleural cavity are the sixth or seventh interspace in the mid-axillary line or the ninth interspace to the outer side of the lower angle of the scapula.

The pleural sacs behind the upper portion of the gladiolus are contiguous, while the sacs behind the manubrium sterni are separated by an angular interval.

Paracentesis is a positive means of determining the

presence of fluid within the pleural cavity, and it should be done to verify the diagnosis before applying surgical methods for its removal. A small aseptic needle introduced through the sixth intercostal space about the middle of the post-axillary line, is the method of choice. If the effusion has not become infected, a larger needle may be introduced at intervals of a few days, with permanent recovery as a rule, but if infection has occurred (empyema) resection of one or more of the lower ribs surrounding the pleural cavity is necessary.

Halmgren recommends two punctures, one above the other; through the upper one air is forced to replace the fluid which escapes through the lower opening. The air also supports the lung until it can expand slowly.

Friedrich proposed total *pleuropneumolipsis*, resection of chest wall overlying tuberculous lung, only applicable in a few cases.

Thoracentesis (Thiersch) for Recent Empyema.—A large fenestrated Nélaton catheter is passed through the sheath of a trocar that has been made to pass through an intercostal space. A rubber membrane with a small orifice is slipped over it and tied fast to the tube where it emerges, thus providing an air-tight closure of the thoracic cavity at the site of puncture or incision. If the Nélaton catheter is continued into a soft-walled drainage tube, which acts after a fashion of a vein, permitting the exudate to escape under increased internal pleural pressure, while it does not allow the entrance of air because of the coaptation of its walls in inspiration, the result is a reliable mechanism which effectually permits the drainage of the exudate and prevents the occurrence of pneumothorax. Practically the meta-pneumonic cases are completely healed by means of this apparatus without further surgical assistance, but not so after the formation of pus focus in the pleura has become encapsulated, for resection of ribs then becomes necessary (Friedrich).

Foreign bodies may enter the pleural cavity through the chest wall, esophagus, the lung from the bronchus, peritoneal cavity or soft structures of the neck. In

either event they are usually infected, and their removal by one or more ribs or cartilages, and like all other operations for drainage of the pleural cavity, should be done with reference to gravity Drainage having been provided for by one of several methods, much care and time are usually required for convalescence.

Neoplasms of the pleura may be primary or secondary, malignant or non-malignant, usually from metastases from the lung, cartilages, bony structures of the chest, periosteum, muscular tissues of the chest wall, mediastinum, pericardium or other parts of the body. Many such growths are amenable to surgical operation, necessitating an incision varying in extent through the pleura. Probably the majority require drainage, with or without infection. They may have become infected before the primary operation, or at any time thereafter. Carcinoma and sarcoma are of most frequent occurrence.

Persistent Thoracic Sinus Following Empyema.—A report of fifteen cases treated by decortication of lung and thoracoplasty. (Charles N. Dowd, New York, *Journal A. M. A.*, October 16, 1909.)

Technique.—Dowd has performed the operation of lung decortication connected with thoracoplasty in fifteen cases in children. In his patients ether was used, the patient lying on the sound side. "Orientation" incision was made about the sinus opening, with resection of three or four inches of the rib above and the one below it. The incision was then carried upward in anterior axillary line to the third rib. The ribs were divided and suitable portions removed, usually one-half inch from the second or third, four to six inches from the tenth, and corresponding pieces from the intermediate ones. Sometimes less was taken away. With suitable retraction an excellent view of the sinus is thus obtained. A longitudinal incision is then made through the upper part of the sinus wall until the lung is reached. At this stage of the procedure the patient is allowed to so nearly emerge from the anesthesia that he will cough, when the lung usually bulges into the incision. The membrane is then separated from its sur-

face over as large an area as is practicable and removed. In most of these cases a strip two or three inches long and from one to two and a half inches wide has been removed. This about represents the pulmonary portion of the sinus lining. The chest wall was nearly brought together by strong sutures, and a drain or suction tube inserted in the unclosed part. The amount of chest wall removed varied according to the case, and according to the likelihood of gaining lung expansion. In every case persistent and continued blowing on James' (or Wolf's) bottle has been used.

Beck states that it is not necessary to drain off the pus from the pleural cavity before injecting bismuth paste in all cases, because thirty to sixty grams will often produce the resired results without rise of temperature. Sinuses will close in a comparatively short time, during which time the secretion remains sterile.

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GANGRENE.

Gangrene may be primary or secondary, and result from disease or injury in either the visceral or parietal pleura. In either case partial thorectomy is necessary for the removal of all diseased tissue, and ample drainage. Disinfectant solutions and gauze firmly packed into the cavity should be freely employed. Nutritious food and stimulation will be the most valuable adjuncts in the after-care.

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Injections of solutions containing different medicaments and gases have been made into the pleural cavity for various purposes for many years, but their value

has never been fully demonstrated. They have been done with various devices, such as needle, with and without syringe. Thermo and chemico cauterants have also been employed with no better results.

Moizard, 1885, injected various antiseptic solutions, while Brockman, 1903, used perchloride of mercury in empyema. Destot-Violet, 1904, applied the X-ray. Ewart, 1905, injected adrenalin, and Payrock, 1909, combined the subcutaneous injection of antidiphtheritic serum with thoracauteries.

PLEURECTOMY.

Pleurectomy has a history which begins with the report of such an operation by de Marchettis, 1692. Resection of cartilages or ribs must necessarily be done before that of the pleura can be accomplished. It is therefore necessary to consider the various methods by which removal of the thoracic wall is done, that the technique may be better understood. These are specified in the appended bibliography for this chapter.

Pleurectomy is the removal of a part or all of the pleura. It is necessary to remove pus, blood, serum, foreign bodies or neoplasms. The blood may come from any of the vessels, large or small, any one of which may become infected. Serum in abnormal amount may be the result of acute inflammation. Foreign bodies may enter from without or within. They may enter from the bronchus or esophagus, or they may pass through the lung into the pleural cavity.

Neoplasms may be malignant or non-malignant, large or small, and parasitic or bacterial in their origin. *Pleurectomy* necessitates the removal of one or more ribs or cartilages, which is also necessary for decortication or thoracoplasty for thickening of the pleura. Within the last few years an operation has been inaugurated by which these conditions may be relieved by removing all the pleura overlying the lung. This may be the costal and visceral pleura united. The obliteration of the pleural cavity is due to union of the parietal and visceral pleura It may be necessary to remove several inches of it, that the lung, like the heart, may be given an opportunity to expand and functionate properly.

The lung alveoli may be at rest for months and then be made to functionate, but if they are destroyed they never do so. If a portion of the lung be removed, the remaining portion will expand to occupy the pleural cavity. In doing so, the alveoli will become distended and elongated, in which condition they lose their function because they cannot contract. *Decortication* is now the accepted operation to give relief in cases of tuberculosis, abscess or adhesions causing the lung to lose part of its functions. There are many invalids caused by this condition who may be relieved in this way, not only with tubercular cavities in the lungs, but with other diseases.

Pleurectomy (Decortication, Thoracoplasty). Sometimes it becomes necessary, when the pleura is greatly thickened from chronic inflammation, to make one or more incisions through it, and remove areas, varying in size, that the lung may be permitted to expand and thereby resume its function. Sometimes it is the visceral pleura alone that is at fault, sometimes the costal pleura, and other times both visceral and costal. They may be united, and the pleural cavity obliterated, or they may not be united, leaving the cavity unobliterated. If obliterated, the thickening is greater and more dense. If not infected, or if it does not become so, convalescence is short, and the after-care simple. If infected before or after, convalescence is slow and the after-care great, owing to continued and profuse discharge.

Visceral Pleurectomy, by *Alexander Hugh Ferguson* (Trans. of the American Surgical Association, 1909).

Technique.—Visceral pleurectomy, decortication of the lung, also named Fowler's operation, may be defined to be the removal by operation of the thickened pleura in cases of chronic empyema. It was first performed by the late Dr. G. R. Fowler, of Brooklyn, a Fellow of this Association, on October 7, 1893, and published in the *New York Medical Record,* December, 30, 1893. Had Dr. Carl Beck, of New York, only published his first case of visceral pleurectomy, which he exhibited to the German Society of New York (letter), then he could have claimed the honor of being

first. The date of publication always decides the question of priority.

A year later Delorme (*Presse méd.*, Paris, 1894) published his case operated on in the same year. Then one by Reclus (*Presse méd.*, Paris, 1894); one by Gallet (*Le Clinique*, January 6, 1895) and then one by myself (*Journal A. M. A.*, January 9, 1897). These four cases of visceral pleurectomy were the only ones recorded up to the date of the meeting of the American Medical Association, at Atlanta, Ga., May 5 to 8, 1896, where I presented a paper on "Thoracoplasty in America, and Visceral Pleurectomy, with Report of a Case," and published the next year, as above stated.

Visceral pleurectomy is a major operation, but not as grave as Schede's operation, although in selected cases these two procedures may be often partially and rarely completely synchronously performed, depending upon the general condition of the patient and the amount of pathological tissue to be removed. It is usually, however, performed after the chest wall has been liberally removed and a chronic cavity or sinus still persists.

Indications.—"The local condition is a suppurating cavity remaining after the ribs, intercostal structures and thickened parietal pleura (Schede) have been removed. The lung is bound down by the enormously thickened visceral pleura, and a further development of granulation tissue seems impossible. Even when tubercular foci are present in the lung, and these are breaking down, the operation may be advised, provided the other lung is sound and the patient is otherwise in a condition to stand it. It is, of course, preferable for the sputum to be free from tubercle bacilli, but if it is apparent that they come from the compressed lung, an operation need not be withheld. Amyloid degeneration of the internal organs, within certain limitations, as found in these cases of chronic empyema, does not contraindicate visceral pleurectomy. That the symptoms of amyloid disease disappeared when the cause was removed by operation, was as well known to surgeons in pre-antiseptic days as it is to us. Special attention must be given to the condition of the kidneys.

from a surgical viewpoint more risks may be taken in cases of waxy kidneys than when chronic nephritis, pyonephrosis or kidney tuberculosis is present. A person suffering with 'cold abscesses' in other parts of the body, *e.g.*, psoas, iliac, lumbar, etc., who also has an empyema, may receive a pronounced turn to recovery after visceral pleurectomy. There is a prevalent idea among the profession regarding chronic empyema which has been treated by thoracoplasty and perfect drainage secured, and that is that it has already received all the surgical treatment available. In consequence there are many neglected cases throughout this country facing the dangers of septicemia, pyemia, amyloid disease and tuberculosis, whose lives may be made comfortable and days lengthened by a timely visceral pleurectomy.

"Just as soon as it is clear that the cavity has no tendency to become obliterated, after bismuth paste injections and the liberal removal of the chest wall, the sooner a visceral pleurectomy—the climax of operative procedures for this purpose—is performed, the better it is for the patient. In children simpler procedures will usually suffice, *e.g.*, curetting, irrigation, Beck's paste, etc. Expansion of the lung does not usually result, unless the lung is liberated shortly after it becomes bound down."

Pathology.—"A study of the thick fibrous pleura in cases of chronic empyema soon convinces anyone that nature cuts off nutrition so effectually from its surface as to render it impossible for healthy granulation tissue to form to close the cavity. Cut section of the pleura shows from within out (*a*) lung tissue; (*b*) fibrous tissue, even cicatricial in character; (*c*) waxy substance, and (*d*) a smooth, pale, glistening surface. Under the microscope (low power) there is no epithelial covering, but an array of granulation tissue consisting of cells, fibers and a large proportion of thin blood-vessels is to be seen. As you go deeper, the proportion of fibers to cells increases, the number of blood-vessels decreases and an infiltrate of homogeneous material becomes more prominent. Deeper still, a large number of blood-vessels is seen in various stages of

obliterating endarteritis. In some of them the lumen is scarcely apparent, while in the vicinity there are masses of concentrically arranged fibrous tissue, exactly similar to the vessels, except that there is no longer a lumen. These whorls of tissue I interpret as blood-vessels that have been entirely obliterated. In this zone can be seen columns of cubical epithelium with no lumen, the remnants of obliterated air vesicles. As we go deeper into what is plainly apparent as lung structure, we find gradation from the just noted to be the air vesicle, easily recognized as such. These air vesicle walls are thickened by an overgrowth of fibrous tissue that in places is even, and in places is knob-like. There is considerable pigment within these alveolar walls. Occupying a portion of the air vesicle is an exudate. The blood-vessels in these alveolar walls are thickened. A bronchiole of small size can be recognized."

High Power.—"Superficial, typical granulation tissue, with a moderate infiltration of a hyaline material, is seen. As we go deeper matured fibrous tissue is found, and the homogeneous infiltrate becomes more prominent. Some of the blood-vessels show active proliferation of the endothelial cells; in others, with very much thickened walls, this proliferation is not so prominently seen. Here and there in these areas are irregular masses of degenerated epithelium, easily recognized, which are clearly representatives of former alveoli. Here also appear double columns of cubical epithelial cells, in which the epithelium is regularly arranged along its basement membrane; these are also remnants of obliterated vesicles. These vessel walls previously referred to are seen to be made up of concentrically arranged mature fibers. The thickening in the air vesicle wall is due to increase in the connective tissue. The epithelium which covers it is everywhere cubical. The apparent exudate which filled many of the vesicles is now seen to be in part due to fibrin filaments, but in the greater part due to masses of epithelial cells lying loose in the vesicle. Many of these cells contain pigment. Cross section of the bron-

chus shows a typical bronchus of small size, lined by a single layer of ciliated columnar epithelium.

"The pathological changes are pretty much the same in all the cases, with the exception of tuberculous changes predominating in some of the specimens removed. In Fowler's case no lung tissue was found in any part of the specimen. In my cases (six), all very successful, a microscopic amount of lung tissue was exsected with the pleura."

Operation.—"Lay open the cavity, preferably by a longitudinal incision in mid-axillary line. The course of former incisions may be advantageously followed. Thoroughly curette the pus-bearing surface and disinfect it with Harrington's solution. Now liberate the apex of the lung by boldly circumventing it with an incision which goes clean through into lung tissue. Turn down a flap of the visceral by keeping close to its under surface and cutting through its attachment to the lung with knife or scissors. During this removal the lung, when somewhat normal, will suddenly expand from the thorax and obscure the field of operation. I have found it necessary to compress the lung with moist gauze pledgets before progressing with the dissection. Should the patient manifest signs of shock at this stage, as did that of Rechus, the operation should not be completed at this sitting. It is preferable to anticipate the bulging of the lung and prevent it by pressure. At the angle where the visceral becomes the parietal pleura the liberation and removal of pathological tissue must be very thorough. When the operation is completed, only skin and external muscle flaps cover the decorticated lung. Should stumps of ribs, as is usually the case, either anteriorly or posteriorly, prevent closure of dead spaces, these must be resected *en masse* by means of powerful bone shears, which plaw through all hard and soft structures at once. The common practice of tearing the ribs out one by one, and then cutting away the soft parts takes a much longer time and is accompanied by far more shock. The operator must at all times keep in mind the limitations of the patient's endurance. I recollect losing a case from shock caused by

too much Ferguson while doing a Schede operation. In the surgical treatment of empyema from thoracentesis to visceral pleurectomy, I am constrained to emphasize the vital importance of rather underdoing than overdoing any one of the procedures at our command at any one time. The one seance operation is, of course, preferable if the patient can stand it. Decortication by slicing away the sclerosed pleura over the apex of the lung, at the angles of the cavity, and beneath the scapula, is disappointing in its results, and sooner or later a more complete resection is imperative to obliterate the old cavities. In most of these cases requiring pleurectomy the object is not to obtain expansion of the lung, but by removing a cicatricial and suppurating membrane the cavity will close by means of granulation tissue, which must arise from the raw lung and surrounding soft parts normally nourished. The unsatisfactory results obtained by Garri, Jordan, Krause and many others may be accounted for (*a*) by incomplete removal of the chest wall, including the costal pleura, or (*b*) by imperfect excision of the visceral pleura. The thorough eradication of the apex of the pleural cavity, which is not touched by Schede's operation, is imperative to effect a cure. The vicinity of the subclavian vessels must not deter the surgeon from removing the costal dome before attacking the visceral pleura. A mid-axillary incision and strong, sharp extractors holding the flaps well apart greatly facilitates this most difficult task. I have not found it necessary to make a temporary resection of the clavicle or resection of a portion of the scapula for this purpose, or resection of the scapula for this purpose, as is suggested by some surgeons."

Value of Bismuth Paste (Emil C. Beck, of Chicago).—"In the preparation of cases of empyema for operation and also in the after-treatment, nothing has proved more satisfactory in my cases than has 33 per cent. of bismuth in vaseline and injected through the fistula into the cavity. It reduces the temperature, renders the cavity comparatively aseptic, and actually

cures cases that otherwise I would have operated upon at sight."

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Pleurorrhaphy is done for lacerations, incisions or puncture, all of which may be regular, irregular, lateral or perpendicular. Such wounds may be simple or compound, septic or aseptic, with or without hemorrhage. They may or may not involve the pericardium or mediastinal space, and they may unite the two pleural cavities so that they may or may not necessitate surgical interference which must be determined by the general condition of the patient. If an operation is decided upon the chest must be opened boldly and quickly, with or without general or local anesthesia. Nearly all of these operations may be done without a general anesthetic. The suture should be chromicized catgut, but it may be fine linen or silk. In nearly all this work the interrupted suture must be used, because if one suture breaks the rest may serve the purpose.

Suturing the pleura cannot be done without removal of one or more ribs or cartilages. It is seldom, if ever, necessary without their removal. It should be done with absorbable suture material, and can with safety be done many times without drainage.

Indications for Pleurorrhaphy.—Lacerations, Incisions, Punctures.

Lacerations vary in extent, and are usually due to trauma, with or without the removal of ribs or cartilages, as in puncture from fracture. Not all lacerations require suture or drainage. They may involve any part of the visceral or costal pleura, and always result in adhesions of the visceral and costal pleura, with or without suture. They are usually infected, and when so require constant drainage. When not infected but little care is necessary.

Incisions are done with a cutting instrument, intentional or by accident, vary in degree and location; if small, through the intercostal space they sometimes do not require surgical intervention. If ribs or cartilages or both have been removed for exploration, or the removal of neoplasms, or foreign bodies, suturing is made easier, but the complications are greater.

Puncture of the pleura may be simple or complicated and vary in degree. They may be through the intercostal space, cartilage or rib, one or all, in any part of the chest wall. If small and uncomplicated, little if anything is required in the way of surgical interference, but if infected or complicated it may be necessary to remove one or more ribs or cartilages, one or both, that free drainage may be instituted. It is only in extensive or complicated punctures that suture is necessary. This may be a part or throughout the extent of the opening, depending upon whether or not drainage be instituted, convalescence is then usually slow.

Technique.—The method and character of suture material to be employed will be governed by the kind of pleural tissue for consideration, whether it be visceral or parietal, also whether the wound is sterile or non-sterile. If visceral or parietal and sterile, small catgut, silk or linen are preferable. If visceral and non-sterile, fine silk or linen should always be employed, because they will hold the tissues together for a greater length of time and afterward become embedded or disorganized after they have served their purpose. These advantages are important, because of the very inaccessibility of the lung. The accessibility of the parietal pleura renders the choice of suture material less important.

Small needles and mattress suture should be employed in all cases if possible, and the intervening suture spaces not to exceed one-quarter of an inch in length.

The post-operative treatment of the various operations upon the pleura is the same, with or without infection, and with or without drainage. Incisions of the pleura may be primarily aseptic or septic. If aseptic drainage may or may not be necessary, but if aseptic and they become infected, then drainage must be instituted by means of gauze, tape or rubber tube. If not septic, irrigation with any kind of a solution should not be done, but if septic it may occasionally be done with sterile water alone, care being taken to see that the outflow equals the inflow at the time of

its introduction. The semi-sitting posture should be assumed as soon as possible after the operation, that gravity drainage may be more certain. If at any time there is bulging of the parts with or without rise of temperature, the wound should be reopened.

In cases where the pleura has been sutured, one or all of such sutures should be divided and removed. All dressings and manipulations of such wounds should be done under strict aseptic precautions.

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A more recent article on empyema by Dr. Edward Pirrung is considered by the author worthy of a place in this chapter:

* * *

The symptoms of suppurative pleurisy do not differ greatly from those of simple or serous effusion. In many case it is impossible (clinically, at least) to make a certain diagnosis. The signs and symptoms of purulent effusion are often less acute in character than they are in serous effusions. The chills are more frequent, the fever continuing for many days and weeks. The pulse is slightly more rapid at the onset and continues at a high rate throughout the course of the disease. The tongue is deeply furred, showing a dry coating, the condition of the patient is septic and anxious. The hectic fever and sweats are constant. The occurrence of drenching sweats, especially during the relaxation of sleep, I have found a quite common symptom in the purulent pleurisies.

Clinical Course.—Pleurisy may begin with pain and fever or the onset may be gradual. Cough of a dry character with stitch in the side. The pain increased by attacks of coughing, the cough producing no expectoration, difficult breathing, the respirations are short, jerky and incomplete. These symptoms and other evidence of pleural congestion concern the chest. These are the most common signs, though frequently all are not present. Many of the cases are secondary to inflammations in the lung tissues, extension from subphrenic infections, or from mediastinal or pericardial involvement. Foreign bodies and new growths are often responsible for the occurrence of effusions within the pleuræ. Occasionally we see empyema result from an overwhelming septic infection involving all of the serous surfaces and cavities of the bodies. Traumatic infected pleurisies and infected hemothorax might also be discussed under empyema. However, only those infections which are carried by the blood and lymph streams, or extensions from the adjacent organs or visceræ, are herein considered.

Purulent pleurisy is seen at all ages, is frequent below one year, increases in frequency up to the age

of five years, from five to twelve it holds a fairly accurate level. From that time on it declines and is an extreme rarity in the aged. The effusions occurring in the adult, middle and the more advanced years are generally serous. In the majority of cases they are primarily tubercular. Serous effusions many times are secondarily invaded by pus-producing organisms, the complication of mixed infection making it quite a serious problem to deal with. Exposure to cold and chilling is a common cause of pleurisy. Poor nutrition and certain general diseases, such as Bright's disease, diabetes and rheumatism, predispose to pleurisy. In children, the acute infections, together with broncho-pneumonia, are frequently followed by purulent effusions.

The purulent pleurisies admit of no other explanation than that of invasion of the pleural sac by pus-producing organisms. The organism producing pus may be the streptococci, pneumococci, the influenza B., the staphlycocci, the coli B., the typhoid, and the B. anthrax is occasionally found. Tubercular purulent pleurisy is not a pure tubercular infection (Koch's B. has no pyogenic properties). Other pyogenic bacteria are found in varying members. A pure pneumococcal pleurisy is rare in adults, but occurs quite frequently in children. Pure cultures are not the rule in adults or children, mixed infections following the acute infectious diseases are quite common. Purulent pleurisy, due to the staphlycocci, is rare and usually follows tonsillitis or osteomyelitis. However, following trauma, gunshots and stab wounds, you may find the staphylococci to be the cause of a purulent effusion.

The physical signs of pleuritic effusions are common to both serous and purulent affections. They are diminished vocal fremitus, absent or alterations in the breath sounds, dullness on percussion, displacement of the heart and diaphragm. (The diaphragm and abdominal viscera are displaced upward, while displacements of the heart are variable.) There is hyperresonance over the area of the uninvolved lung. A triangular area of dullness with the apex at the sternoclavicular junction on the affected side. The so-called skodiac resonance (this symptom occurs only in free

effusions when the lung is unattached by adhesions to the parietal pleura.) Other signs and symptoms may be intercostal bulging, signs of fluctuations between the ribs and absence of the respiratory excursions on the affected side, while in children there is an apparent flattening of the chest wall.

Signs indicating the nature of the fluid may be sought for in a careful study of the onset and course of the disease, the presence of other diseases or complications, the temperature, the pulse rate, together with the drenching sweats and the other septic phenomena may help you to separate the purulent from the serous effusions. A blood count will show a leucocytosis of marked degree. Examination of the aspirated fluids will reveal the true nature of the disease, either through staining method, cultivation on artificial media or by animal inoculations. In a tubercular case, where mixed infections have occurred, it may be extremely difficult or impossible to isolate the tubercular B. Concerning failure to find fluid or pus, they may be encysted or interlobular and require several punctures to locate; then, too, the consistency of the fluid may be so great that it will not pass through the needle. If the empyema is of long standing, the exudates becoming organized in the fibrinous bands, bind down the lungs and the persistent irritation will cause great thickening of the pleura.

The first essential of a successful treatment is an early and accurate diagnosis. If operation is indicated, it should be one of choice and not of necessity. Surgery in the exploration of the "pathology of the living" has revealed to us the fact that early intervention is essential in all suppurations. Delays usually mean increasing invalidism for the patient; it also means that he must be content with his disability without the hope of permanently restoring the functions of the invaded organ. The indiscriminate operating in pleural infections should be condemned. It is, however, that errors are due many times to neglect upon the part of the physician or surgeon in attributing the condition to unresolved pneumonia, pleural thickening, etc., or whenever pleural effusions are properly

recognized, they are temporized with for too long a time. Again, some physicians believe they must have present all of the signs of effusion without those of lung involvement for a diagnosis. Both frequently coexist; many times some of the positive signs are absent, yet the physical findings—the X-Ray and the aspirating needle (always under strict surgical precaution)—will reveal the true nature of the disease. One should not depend upon the graphic method alone for diagnosis; however, the X-ray should be utilized more frequently. The X-ray will also help in determining the efficiency and completeness of drainage after operation or aspirations. Tardy and repeated aspirations or small incisions as a curative measure should be superseded by the more direct method of rib resection or large incisions if he will check up his aspiring efforts with the use of the X-ray. The post-operative plate will positively reveal the fact that there is still remaining a residue of fibrinous exudates and pus that can not pass out through the needle. A study of the statistics table of the mortality and morbidity of empyema will prove that the advance in the surgical treatment of purulent effusions within the pleural sacs have not kept pace with the modern treatment of infections and pus collections in other parts of the body. It is axiomatic in surgical practice to establish free drainage of pus collections wherever they are found. From the earliest history of medicine, paracentesis of the pleura has been practiced, but, exposed to varying fortunes like every other therapeutic measure, it has occasionally been almost abandoned entirely or reserved for the almost hopeless case. Trousseau says "it was resorted to distrustfully and then only when imminent peril justified extreme daring." Suppurative pleurisy is essentially a serious disease, and, indeed, it generally proves fatal if unrelieved either by surgical meas or by natural drainage efforts in perforating through a bronchus, the pus being coughed up, or it may appear in the mediastinal or peritoneal cavities. Occasionally we have pus appearing externally, viz., empyema necessitas. It does not particularly matter whether the dis-

ease is primarily a purulent or a simple effusion that later becomes purulent—both carry serious consequences if unrelieved. Procrastination is as serious in empyema as it is in appendicitis. I am convinced that two factors are responsible for the neglect of these cases: First, our notions of the pathology have come from the postmortem table; second, operations have been made through small incisions in the pleura; thus we have had little opportunity to thoroughly examine the interior of the cavity.

Treatment.—What is required is to establish early and adequate drainage of the entire pleura. This can only be accomplished by incisions large enough to allow for the thorough exploration and examination of the pleura cavity with the gloved finger. Drainage should be continued for several days in acute cases. The subacute and chronic cases will require drainage over a longer period of time. The opening should be made in the most dependent part; however, it is a pretty good rule to follow that you cut down along the needle puncture wherever pus is found, the needle in the purulent cavity acting as a guide. Do not forget in making punctures that quite frequently the diaphragm is displaced upward. Care must, therefore, be observed in order that the needle does not penetrate below the diaphragm. If aspirations have been repeatedly made, and whenever long delays have occurred without free drainage having been established, we can not hope for sufficient expansion of the lung to again occur as will meet the chest wall. Obliteration of the cavity in such a case may come about by the organization of calcifications of the exudates, or by collapse of the chest wall. Operations which narrow the chest, allowing the chest walls to meet the collapsed lung, are required in chronic cases. Complete removal of the bony chest decortication of the lung and incision of the pleura for the relief of the late results of empyema are unsatisfactory; even if a life be saved, the function of the lung is impaired; thus the man is handicapped in earning a livelihood or his existence is shortened by some intercurrent disease. Such cases are extremely liable to have

disease arise in the other lung, and whenever it does occur, there is no substitute to compensate. Many times death will occur from a low-grade inflammation of the remaining lung.

What can we offer in the performance of early operations? If operation is performed early, before fibrinous adhesions have bound down the lung, we can expect recovery with almost perfect expansion of the compressed lung. Early operations will cast aside complications of joint and spine deformities. What, then, are the objections ocered by the ipponents of early surgical intervention? The first objection offered is that you admit air into the pleural sac, thus destroying the negative pressure and allowing a collapse of the lung; since the lungs are always tending to collapse, respiration becomes impossible, directly free openings are made into the pleural cavities on both sides. According to Starling, after full inspirations the elastic forces are brought into play and the negative pressure reaches as great an amount as 30 m.m. of mercury. The negative pressure in the thorax is diminished by any factor decreasing the elasticity of the lung tissue; thus, in an old man, when the elastic tissue is degenerated and the alveoline enlarged, giving rise to the conditions of emphysema, the lungs may collapse only slightly or not at all on opening the chest. The lungs do not collapse on making an opening in the chest of a new-born mammal, but this is owing to the fact that they completely fill the thorax in the expiratory position and it is only later, with the growth of the ribs, the thorax, so to speak, becomes too large for the lungs, which are, therefore, stretched to fill it. The force exerted by the inspiratory muscles is all spent in overcoming the elastic resistance of the lungs and costal-cartilage. According to Cotton, of Boston, not less than five factors come into play in determining the intra-pleural pressure:

1. The positive pressure of the expiration.
2. The negative pressure of inspiration.
3. Elasticity of the lungs.
4. Lymphatic absorption that clears the cavity of

fluids, but is actually a result of the pressure factor rather than an active agent in determining pressure (as far as we know).

5. The surface tension of the great pleural surfaces, tending to preserve their contact.

Summary.

1. Purulent effusions are often unsuspected or mistaken for unresolved pneumonia or other intrathoracic complication.

2. When correctly diagnosed they are too often temporized with by aspirations.

3. Whenever operation is performed, drainage is often inadequate.

4. The operation of choice is an early and wide incision of the pleura.

5. Excision of a rib or ribs may be required for adequate drainage and exploration.

6. Our efforts to improve the statistics of empyema can only be brought about by a more careful and accurate diagnosis and resorting to earlier operation intervention.

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SURGERY OF THE LUNGS.

PNEUMONOTOMY.

BY B. MERRILL RICKETTS, M.D.,
CINCINNATI.

The normal number of lobes of the lung varies. Some animals have but one, while others have several, and the number may vary in each individual. Anomalous numbers of lobes are frequent, but it is difficult to ever determine such variations. The minute structure of the lung and the number, size and distribution of the bronchi also vary considerably, as does the structure of the alveolæ of man. This is the only instance of capillaries being found on both sides of the alveolar walls, and there is no reason assigned why this is so. No doubt it adds greatly to the process of repair, necessitated by inflammatory changes. The lung of man is therefore the most highly developed of all animals.

Embryology.—"On the fifteenth day there appears a swelling on the floor of the pharynx, opposite the first, second and third bronchial arches, and along the middle of this swelling runs a longitudinal groove. This groove becomes more distinct on the sixteenth day, and its posterior end terminates in a short ovoid pocket, which becomes deeper by the end of the third week, and extends backward to the side of the esophagus and independently of it; and its posterior end becomes divided into right and left lobes, which afterwards become the lungs proper. The tube leading to them is the trachea, and the slit opening into the groove on the floor of the pharynx is the future glottis. During the fourth week the lungs are growing rapidly on each side of the esophagus and dorsal to the heart. The distal end becomes larger and soon divides into lobes, three on the right and two on the left, so that the fifth week finds the main lobes becoming greatly elongated with budding, which process continues with

the development of the air cells, which are not recognizable until time of birth."

The X-ray should be employed in all extra and intrathoracic conditions for diagnostic or thora-pleuritic purposes. It has been employed as a therapeutic agent in a few forms of extra and intrathoracic neoplasms, especially Hodgkin's disease, which has been greatly benefited but not cured, and hypertrophy of the thymus gland, which has been apparently arrested if not diminished in size.

It is a valuable aid in detecting neoplasms, aneurisms, abscesses, blood and serous cavities, foreign bodies and traumatic lesions varying in character. Sinuses, especially when filled with bismuth, can also be readily traced.

Atelectasis is collapse of the lung before birth, due to compression by fluid, new growths, deformity or paralysis.

Apneumatasis is collapse of the lung after birth, due to the same and additional causes (pneumothorax).

Treatment.—Surgical intervention on the affections of the lung may be classed under four different headings:

1. "Intrapulmonary interference with diseased foci.

2 "Influencing of pulmonary affections by way of the pleura, through compression of the lung.

3. "Operative procedures on the thoracic wall, for the mechanical influencing of the pulmonary function, thereby reacting on pathologic processes in the lung.

4. "Operative treatment of the diseases of the thoracic wall itself, in as far as this leads to the exposure of the lung." (Friederick).

PNEUMONOTOMY.

Pneumonotomy comprises all incisions and punctures for any purpose. Any portion of the lung may be incised or punctured for exploration, injury, disease or experimental purposes, with comparative safety, now that pneumothorax is so readily overcome.

Lung Puncture.—Horder (*Lancet*, November 6, 1900) punctured the lung for diagnostic purposes in some fourteen cases. He says it may be done in ac-

tual practice under two conditions: (1) If a pleural effusion is suspected and the result of the puncture negatives this; (2) if no fluid is suspected in the pleural sac, but the lung is deliberately punctured for the express purpose of discovering the nature of the disease process within the lung itself. The material obtained is no less valuable in the first than in the second of these two conditions. The indications given by the author for penetrating the lung are as follows:

1. In any case yielding signs of consolidation of the lung, in which careful examination of the sputum fails to reveal the nature of the disease. It is perhaps pushing the value of "ocular demonstration" rather far to say that the lung puncture is indicated in a straightforward case of lobar pneumonia, even where there is no sputum for examination. But it should certainly be undertaken in any such case if the desired clinical course is departed from in any way to the prejudice of the patient. The puncture will frequently reveal the existence of a mixed infection (*e.g.* B. influenza and pneumococcus) when this is not suspected.

2. In abscess it is useful to obtain a specimen of the pus from the actual seat of suppuration, for thereby a knowledge of the causal microbe is gained, often a matter of great difficulty or impossibility when dealing with sputum.

3. In bronchiectasis the same comments hold. Lung puncture may possibly be of service in suspected cases of acute pulmonary tuberculosis, in which condition sputum is so commonly absent. Lung puncture is performed in exactly the same manner as pleural exploration.

INDICATIONS FOR PNEUMONOTOMY, CYSTS, ABSCESS, NEOPLASMS, FOREIGN BODIES.

Cysts may be serous, pyogenic or hemorrhagic, large or small, single or multiple. The pyogenic variety may become violently active, and those not pyogenic may become pyogenic.

Echinococcus.—About 15 per cent. of all cases found in the human body are of the lung, and they are usually secondary. The normal cyst fluid contains min-

Ronce, H.: Kystes hydatiques du Poumon. Paris Thesis, 1907.
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Albertin, H., and Barjon, F.: Lyon Chirurg., iii, 149-160, 1910.
Marquis, L.: Hydatid Cyst Infant. Arch de med. des Enf., ii, 657, 1908.
Lozano, R.: Clin. Med., Zaragoza, viii, 723-735, 1 pl., 1909.

Actinomyces, due to the ray fungus, so commonly observed in those who work with maize and animals, may be found primarily in the lung. The left lung is most commonly involved, though direct infection is very much questioned.

Treatment is very unsatisfactory. Iodide of potassium by mouth and subcutaneously in 1 per cent. solution, in one-half drachm doses every third day, have been recommended.

Method of Operation.—Complete eradication is necessary, or any attempt to cure will fail. The knife and cautery must be freely applied. Garre records ninety-six cases of the lung operated upon, with eighty-seven cures.

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Psittacosis.[1]—Gilbert and Fournier have studied an epidemic of psittacosis. This is a disease transmitted from birds, particularly parrots, to man. In birds it

1. The American Year Book of Medicine and Surgery, 1898.

is characterized by marked diarrhea, loss of appetite, depression and loss of feathers. In man it runs the course of an intense typhoid fever, without abdominal symptoms, but with marked pulmonary disturbances, resembling a severe infectious pneumonia. A marked epidemic occurred in Paris in 1892, affecting fifty persons or more. The cases studied by the authors occurred in February, 1896, and affected five persons, of whom two died. They were able to confirm the observation of Nocard regarding the occurrence of a definite bacillus, having found it in the cases under their observation as well as in the bone marrow of the birds. They could not find the organism in the blood of the patients during life, but they did find it in one case in the blood of the heart, post-mortem. The organism resembles the bacillus of Eberth in a number of particulars. It is extremely virulent, causing death in rabbits, mice and pigeons within fourteen to forty-eight hours.

An editorial in the *Gaz. heb. de Méd. et Chir.*, April, 1897, discusses psittacosis. It was introduced into Paris in 1891 by some parrots from South America. It may be transmitted either from the parrots to man directly, or through intermediate objects, or from other men. The period of incubation is from seven to twelve days, the disease commencing with malaise, epistaxis and disturbances of the digestion. This is followed by bronchitis or bronchopneumonia, with slight albuminuria, and finally there is high fever, which appears very early and lasts three to four days, and terminates by crisis. These phenomena may recur several times, defervescence finally taking place by lysis. During the course of the disease the spleen is enlarged, and the signs of pneumonia may be more or less pronounced. In some cases an eruption has been present, at first roseolar and subsequently petechial. Three forms are recognized, the slight, nervous and ordinary. The duration of the whole disease is about thirty days. If no complications occur, recovery is the rule, but the mortality is about 37 per cent. The cause appears to be the bacillus discovered by Nocard, which closely resembles the bacillus of typhoid fever. Curiously

enough, a reaction analogous to that of Widal does not seem to occur in this disease. The treatment is purely symptomatic, prophylaxis being by far the most important part.

In 1879 J. Ritter[2] reported (*Deutsche Arch. f. klin. Med.*, 1879, Bd. xxv, p. 53) a house epidemic of severe pneumonia which he ascribed to contagion from parrots, or rather the cages in which the birds had been transported. Similar observations were made by Ost (*Corresp. Blatt f. Schweizer Aërtze*, 1879, No. 19) in Berne in 1882 and by Wagner (*Deutsche Arch. f. klin. Med.*, 1884, Bd. xxxv; 1888, Bd. xlii) in Leipzig, in 1882 and 1886.

In December, 1891, five hundred parrots were purchased in Buenos Ayres for the Paris market. Of these, three hundred died on the voyage, and two hundred reached Paris in February, 1892. During that year there were forty-nine cases of the disease now known as psittacosis, ascribed to infection from these parrots, with sixteen deaths; in 1893, seven cases with five deaths; in 1894, two cases, both of which recovered; in 1895-96, twelve cases, with three deaths.

In 1894 there were house epidemics in Florence and Ponto, of a malignant atypical pneumonia, appearing simultaneously in several members of the same family, or even involving the whole family, and in some instances conveyed directly from one individual to another. This visitation was ascribed to parrots which had been imported by way of Genoa from South America. Observations (Leichtenstern, *Centralbl. f. allgem. Gesundheitspflege*, 1889, 18) were made by Banti, Malenchini and Palamedessi (*Centralblatt f. Bacteriol. u. Parasitenkunde*, 1896, 20).

In 1897 it was reported (*Lancet*, 1897, p. 1058) that in Genoa fourteen persons fell sick and eight died because of two parrots brought from Brazil.

In 1898, in the Julian Venetia, three inmates of one house fell sick, and of these two died, where two parrots died shortly before. Leichtenstern (*Centralbl. f.*

2. Trans. Assoc. Am. Phys., vol. xiz, p. 364, 1904, Herman F. Vickery, M.D., Boston.

allgemeine Gesundheitspflege 1899, 18) observed house epidemics in Cologne in 1898.

In one there were ten cases and four deaths; in a second eight cases with one death. Leichtenstern regards it as probable, but not susceptible of absolute proof, that both these groups of cases were referable to contagion from parrots.

In 1880 Eberth reported the discovery of enormous numbers of micrococci in the body of a gray parrot, and in 1883 M. Wolff (E. Mace, Traité de Bacteriol., 1901, p. 408) examined the bodies of twelve gray parrots from the Guinea coast with the view of explaining the immense mortality in parrots brought thence to Germany. He also found micrococci in great numbers.

In 1893 Nocard (Warthin, Reference Handbook of Medical Science, vol. vi, p. 779) isolated a specific bacillus belonging to the group of colon bacilli.

Among the Florentine cases, Palamidess (already mentioned), in a house epidemic which attacked five persons in one family, a few days after a South American parrot was introduced, found a microbe similar to the bacillus of chicken cholera, but more like Nocard's bacillus, though apparently not identical with it.

In 1896 Gilbert and Fournier (*Bulletin de l'Acad. de Méd.*, 1896) reported five cases of psittacosis in man; of these, two died. In the heart's blood of one, Nocard's bacillus was found post-mortem. It proved to be an extremely virulent organism, killing rabbits, mice and pigeons within fourteen to eighteen hours after inoculation.

Nicolle (Comptes rend. Soc. de Biol., December 30, 1898) reported in 1899 an epidemic affecting eight persons, of whom four died. He did not find Nocard's bacillus. He did obtain a serum agglutination from a culture of that bacillus in dilutions of 1-50 and 1-60. The serum also caused a clumping of typhoid bacilli, although the patient had never suffered from typhoid fever; but Widal (*Medical News*, January 9, 1897) and Sicard (Leichtenstern, *Centralblatt f. allgem. Gesundheitspflege*, 1899, 18), 1896, claimed that they could differentiate the typhoid bacillus from Nocard's by the serum reaction.

The symptoms of the disease in parrots are loss of appetite, debility, drooping of the wings and diarrhea, ending with convulsions and death. In man, the symptoms of the Paris epidemic might be summarized as those of a grave typhoidal condition with atypic pneumonia. The onset is acute, often with chilliness or a true rigor. Exceptionally the disease begins insidiously, but in that case there is apt to be a chill when the pneumonia begins. The temperature is often 103° on the first day and perhaps 104° on the second day of the illness. The fever is more or less continuous, with a termination by lysis. In many cases successive foci of pneumonia develop, giving the temperature curve a recurrent type.

With the onset the patient is feeble and depressed; he usually has a violent headache and is often dizzy. There may be delirium. As a rule, there is obstinate constipation, but some cases suffer from diarrhea. The spleen is often enlarged. There may be a roseolar eruption or petechiæ. From the beginning of the disease there is a noticeable cough, and on auscultation subcrepitant râles are found throughout both lungs; then after a few days there is a slow development of pneumonia, which may be either lobular or lobar. In some cases, however, there may be no evidence of consolidation.

In the cases reported by Leichtenstern, above referred to, the illness was similar. There was the greatest weakness and depression from the start, and almost invariably a severe headache, but no cases had delirium. As a rule there were no abdominal symptoms. The spleen was not found to be enlarged in any of the cases, thus contrasting with the Paris epidemic. The period of incubation varied from one to three weeks, in the Paris and Cologne epidemics. Warthin states that it is from seven to twelve days. The mortality is put at 37 per cent. The disease is said to be more severe in the elderly. Treatment is purely symptomatic.

Czaplewski made bacteriological investigations in Leichtenstern's cases. He sums up as follows: (1) The parrot which he examined did not die of infection from

Nocard's bacillus. (2) No conceivable etiologic connection can be proved between the disease of the parrot and the illness of those in whose house it was. He adds that he does not at all wish to deny the possibility of the existence of a genuine infectious disease in parrots communicable to man.

As Warthin states, "the bacteriology of psittacosis and the true relations of the parrot disease to atypic pneumonia seen in man are yet to be definitely determined."

Comparative cases are given.

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Dermoid cysts do not occur frequently within the lung. They may be detected by means of the X-ray, especially when teeth or bony structures or the amount of hair is sufficient to produce a shadow. They are favorable for extraction and drainage, which always necessitates thoracotomy, varying with size and location of the cyst.

All varieties should be drained, and when the lung or cyst wall has become adherent to that of the chest, due to previous irritation or suture, it is much simplified. If not already infected, they may become so at any time during convalescence, and terminate fatally, or be of but little consequence.

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Abscess may be single or multiple, and vary in degree and depth, usually tubercular, but they may be due to infarct, foreign body or pathologic organism, and require drainage through the bronchus or thoracic wall. If of tubercular origin, all operative measures should be delayed until acute symptoms have subsided, especially if there is metastasis.

Abscess and gangrene lesions of the lung require suturing of their diseased segments to the thoracic wall (pneumopexy). However, it is impossible to accomplish this in many cases before or even after rupture.

Surgery of Pulmonary Abscess.—The fundamental principles of surgery are often discovered by accident or surgical trauma. This has been so with the surgical treatment, by incision, of abscess of the lung, as demonstrated by Beligny, 1670, who gives what is supposed to be the first report of drainage by incision of such an abscess. The case was one of pulmonary abscess, which recovered after an accidental thrust into it of a sabre.

Balgious, 1710, however, gives the first account of treating wounds of the lung by deliberately incising the pleura. His aggressiveness is demonstrated in his

advice to incise pulmonary abscess. He was succeeded in this thought by Bligny, 1720, and Bary and Boerhave, 1726. Since then there is much evidence to show the spirit of progress in such pathologic lesions. There has been no cessation in this progress, however slow it may have been, a more perfect technique having not been developed until recent years.

Even now its adoption is slow, though its necessity has been proved in the face of much opposition. In no other tissue or organ of the body, unless it be the heart, would the presence of an abscess be tolerated for so long a time. It is the most frequent lesion found within the lung, and it is due to many causes. Among the more common in the order of their supposed frequency, are tuberculosis, pneumonia, foreign bodies and injury, each of which must be associated with one or more of the infectious micrococci. There may be one or more abscesses when due to any cause, but they are more frequently multiple when of tuberculous origin, and their most frequent location when tuberculous is in the base of the lungs, non-tuberculous abscesses being less frequent in this locality. However, when due to either cause, one or all lobes of one or both lungs may contain one or more abscesses at the same time, or one or more lobes of each lung, or one entire lung, may be destroyed without causing dissolution.

Methods of Operating.—Drainage and obliteration of the cavity are the basic principles in overcoming pathology of pulmonary or abscess in any other tissue; but as the lung is suspended in a cavity surrounded by a resisting osseous and cartilaginous structure, it is exceedingly difficult, many times impossible, to secure such obliteration, though drainage may be had for an indefinite length of time. Various methods have been devised to secure these two essentials, with results more or less gratifying.

The first and probably most important of the two requisites is drainage, because without it nothing can be accomplished. Drainage would therefore be absolutely necessary, while obliteration of the sac would not be so, because life is frequently jeopardized if permanent drainage be induced. The first object, therefore,

would be drainage by a method most appropriate for an individual case, and the second would be obliteration of the sac.

The methods of drainage having for their object perfect drainage would be the most desirable. Those which include this essential concern the removal of one or more ribs within the shortest space of time, and without pulmonary anesthesia. As a rule, it is infinitely better to remove several ribs, because the two essentials, drainage and collapse of the walls of the cavity, are secured. This method is especially desirable if the work can be accomplished at one sitting. However, if for any reason this cannot be done, drainage may be secured at the first sitting by simple puncture (if the lung has become adherent to the chest wall) through an intercostal space, or by removing but a small portion of one rib, and several ribs removed subsequently with an improved physical condition. These remarks have reference especially to but a single abscess, the rule being that the number and amount of ribs to be removed should correspond with the amount of lung tissue involved, whether due to one or more abscess cavities, and their location.

Compression of the lung with gas, air or the various medicated waters, and the injections of medicaments into the pyogenic sac, have appeared upon the surgical horizon since Porral, 1829, who used gas only to vanish into oblivion. Whalen (*Ill. Med. Journal*, May, 1911) states that the lung may re-expand after it has been compressed three years.

Bismuth Paste.—A more recently discovered remedy, has been injected into the abscess cavity, with some degree of success, only where there is an external fistulous tract through which it should escape, because of the great danger of poison from the bismuth alone, or when combined with arsenic. Their constitutional effects are almost identically the same.

With the absence of pulmona-pleural adhesions several inches of one rib may be removed subperiosteally, a linear incision made through the pleura, and the lung sutured to the longitudinal edges of the pleura.

After they have become firmly united, which gener-

ally requires five or six days, the abscess may also be incised. By this method the contents of the pathologic cavity may escape without danger of infecting the pleural cavity, such a procedure having been suggested by A. H. Ferguson in a personal interview upon the subject. However, the propriety of a two-step operation, must not be accepted too eagerly, for all cases requiring drainage, with or without the presence of adhesions, for many such cavities have been successfully drained with total disregard of adhesions and aseptic rules.

Kuhn's mask allows the inspiration through the nostrils, the nose being slightly compressed, while the expiration is effected freely through the mouth, and in this way a hyperemic stasis of the lungs is brought about. Dr. Willy Meyer, of New York, asserts that by using the Kuhn mask he has produced in patients an increase of white corpuscles, hematin and hemoglobin. In connection with Dr. Meyer's statement it would not be inopportune to remember that in cardiac diseases, in which there is a passive pulmonary stasis, tuberculosis is of the greatest rarity. Again, the positive results of the sclerotic method in external tuberculosis should suggest the idea of using injections of sclerogen in the pulmonary parenchyma.

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Neoplasms.—Probably the most frequent primary neoplasm found in the lung is carcinoma. It is quite commonly found there as the result of metastasis.

Malignant or non-malignant neoplasms often necessitate removal. They may or may not be infected, and convalescence is usually of short duration. If, however, any of the lung tissue has been sacrificed, drainage should be instituted, and the after-care is much the same as that for incision for other purposes.

Malignant neoplasms such as sarcomata, carcinomata, and lymphomata of the lungs offer but little for operative surgery alone, unless they are excised during their earliest development, but when sero or electro-

therapy are combined with surgical treatment a few may be benefited if not cured.

Kuttner reports two cases of primary cancer of the lung in which he relieved distressing cough, offensive sputum, and dyspnea, by removing parts of the growth and drainage of the secretion.

Primary Cancer of the Lung.—Primary epithelial cancer of the pulmonary parenchyma is a rare process. It appears to be slightly more frequent in men, especially in those exposed to the vapors of arsenic.

In a careful study of the subject, Ballet (*Thèse de Lyon*, 1910) points out that the symptomatology is not always clear; there are pain, dyspnea, cough, pink colored sputum, and sometimes retraction of the thorax. The concomitant lesions lessen the value of the stethoscopic findings, such as dullness, diminished vibration, weak respiratory murmur, and pleural friction sounds. Râles are present only when other lesions develop. Compression of the trachea, bronchial tubes, esophagus, and nerves may arise, while the supraclavicular lymph nodes are occasionally enlarged. Cachexia occurs late in the process, and the temperature is only slightly raised.

An acute pulmonary edema has frequently led to the erroneous diagnosis of an acutely developing cancer, but in the latter disease the progress is chronic, with intercurrent attacks of bronchitis or pleurisy. The fluid collection of the latter is quickly reproduced, and aspiration in no way changes the signs and symptoms. It should also be pointed out that the clinical manifestations of the pulmonary neoplasm may be overshadowed by distant symptoms, cerebral, for example, or its evolution is quite latent.

The process takes on one of three types, namely, the chronic, pulmonary, pleuritic or compressive. Death takes place in most cases from secondary infection.

To make the diagnosis, one should resort to microscopical examination of the sputum and cytology of the pleural effusion. The former may reveal the presence of cancer cells, either isolated or in clumps. In the pleural fluid, which is frequently hemorrhagic, one

should search for glycogenous cells and those offering fatty or vacuolar degeneration.

Non-malignant growths, such as dermoid cysts, lipomata, osteomata, chrondromata and papillomata, often necessitate removal.

DIAGNOSIS OF NEOPLASMS.

Diagnosis of neoplasms (lung) is obscure and difficult, especially in their earlier stages when the best results are obtained from surgical measures. In their advanced stages their presence is more easily determined, though their character may not be known without the use of the microscope before or after death.

Hansemann reports seven hundred cases of carcinoma of the lung discovered at autopsy, one hundred and fifty-six having not been diagnosticated as tumor of any kind. Sixteen were primary cancer of the lung and bronchi. Fifty-eight were considered as cancer, but were not. Indeed, autopsy often fails to reveal the true condition without the microscope.

Marfan gives two groups as follows: 1. *Cancer pleuro-pulmonaire aigue ou galopant.* The acute or galloping form; extremely rapid course, cough, dyspnea, asphyxia, death in a month or thereabouts. One is led to think of acute miliary pulmonary tuberculosis, and at autopsy both lungs and pleura are found studded with cancer nodules (acute miliary carcinosis). This form need not detain us. It is not only extremely rare, merely a few scattered cases having been reported, but there is reasonable doubt of its primary character when found in the lung. Granted, however, that it does occur as a primary pulmonary lesion, it seems practically impossible to secure a correct ante-mortem diagnosis. 2. *Cancer pleuro-pulmonaire chronique.* The ordinary chronic form of cancer of the lung. This may again be divided into several subordinate types. It must be remembered, however, that these groupings are merely for the convenience of the clinician, and do not represent strictly limited and firmly established syndromes. With the progressive development and extent of the lesion, one of the so-called types may gradually merge into another, and it very frequently

happens that several or all of the forms here mentioned are exemplified in the course of a single case. (Adler).

Chronic bronchitis may indicate early carcinoma, especially if the mucus is stained with blood, percussion dull over apex, voice diminished and breathing shallow and rapid. All of these are usually intensified as the disease progresses to a time when fever, night sweats and hemorrhage make their appearance. If the lower lobe is involved the difficulty of diagnosis is lessened, so that tuberculosis may be eliminated with comparative safety; but if cancer is in the upper lobe there is greater difficulty. Tuberculosis and cancer may possibly exist in the same lung, primarily or secondarily, and when this is so the signs of tuberculosis obtain when tubercle bacilli are found, even though cancer may be suspected.

Sarcoma is rare, and with less metasis than carcinoma, 5 per cent. of which when found in the body are in the lung, and of the medullary form when metastatic. Primary cancer of the lung is the exception when compared to the cancer of the bronchi, which are almost invariably the origin of cancer of the lung. The lung becomes involved by gradual infiltration. However, rare cases of primary carcinoma of the lung originate in the alveolar epithelium, but, as a rule, it is less extensive and malignant than the bronchial type. Certain kinds of sarcoma extensively and rapidly involve the lymph nodes of the mediastinum, but carcinoma which usually produces large solid masses filling the pleural cavity do not do so. Sarcoma does not cause enlargement of these lymph nodes. Pain, which is always present in carcinoma, is not so frequent with sarcoma, unless of large size. Lung tissue of itself is not sensitive, so that great pressure is necessary to cause pain of distant nerves.

Pain in the chest and shoulders is very common and its increase is proportionate with involvement, as a rule, of the bronchus and bronchial plexus.

One in health may be suddenly afflicted with heart, cord, brain, or liver symptoms, varying in degree, as the result of metastasis from an unsuspected cancer of the lung.

Shortness of breath is *constant* and increases with growth of tumor, which causes *substernal tracheal pressure.*

Cough is usually early, but may not appear until later stages, hacking *persistent.*

Bronchial swish (Carnage) may be heard over the hilus of the lung near the spine; always suspicious. Strength, weight and general appearance may be normal, and yet patient near to dissolution.

Sputum.—Prune-juice color not constant, and is often absent. When present is significant. As a rule, color, red. Cancer particles may not appear in sputum.

Hemorrhage, when sudden, is the signal for suspicion of cancer.

Lenhartz says that there are certain cells found in carcinoma of the lung that are not found elsewhere. They are filled with fatty granules supposed to be derivations of degenerated cancer cells, and while they may disappear periodically, they do not close permanently. Milk in the sputum will destroy their identity.

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Foreign bodies within the lung are quite frequent, and their removal many times necessary. If not infected they usually become so, whether their presence is of short or long duration. Drainage is essential in the majority of cases.

Retained foreign bodies in the lung and bronchi have been of frequent occurrence.

Buchtfield (1671) was among the earliest writers to publish cases of foreign bodies in the lungs. Since then a great variety of foreign bodies, among them leaden missiles, have been found within these organs. One of the earliest is that of Moore (1847), who states that he found a leaden missile in the lung, in which it had been buried for fifty years, without causing serious trouble. Warren (1857) found pistol balls suspended within the chest by the pleura eight years after their entrance. Thus it has been shown that death does not necessarily result from the presence of bullets within the more vital structures of the body. However, the question of their removal primarily or secondarily to their entrance into living tissues remains unsettled, though their locality may be definitely determined by means of the X-ray. Such surgical treatment can only be determined in each individual case. With the presence of pain, discomfort, disability or infection, or all, there should be no question as to the course to pursue, which would be the removal of the foreign body.

Technique for removing foreign substances from the parenchyma of the lung has been very much simplified. It is necessary to do it through an opening in the thoracic wall, the size and location of which will depend upon the character of the work to be done and location of the foreign body in the lung. Drainage, which is best accomplished by means of pneumonopexy, should, as a rule, be instituted and maintained until the cavity from which the substance has been removed has closed, especially when infection is present. In but a few instances is it safe to do suture of the [illegible]marily, because primary hemorrhage of any

very great amount should be controlled by ligature, while that of lesser degree may be controlled by packing the cavity with gauze saturated with a solution of adrenalin 1-2,000, or alcohol 97 per cent. Secondary hemorrhage may be controlled by forceps or packing saturated with the same styptics.

Greater care should be exercised in giving titles to papers and case reports, because they are often misleading. This error is especially evidenced in those pertaining to foreign bodies, many indicating that they are within the bronchus, when they should be within the parenchyma of the lung, others within the parenchyma when they mean bronchus. While it might be stated that there is a distinction without a difference, its value is underestimated.

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PNEUMONECTOMY.

Pneumonectomy.—Extrathoracic amputation of lung tissue has been done successfully for many years, but intrathoracic amputation has only recently been accomplished in man. The experimental work was carried on for twenty-five years before any attempt was made to excise a portion of a living human lung, except for hernia. This, however, can now be, and is accomplished with comparative safety.

Excision of the lung may be done by knife and suture, clamp and cautery, or by transfixion ligature made of silk or linen.

Enucleation of a lung that is firmly adherent to the thoracic wall is hardly to be commended.

Technique.—Of the several methods suggested, that of Meyer is probably the most desirable. Circumstances, will, however, govern individual cases, so that no one method can be recommended universally.

1. One mass silk ligature around the bronchus and its vessels; amputation; cauterization of the mucosa of the stumps with pure phenol or the Paquelin cautery.

2. Elastic mass ligature around hilus; removal of lobe at second sitting (Lenhartz).

3. Ligature and division of main bronchus; remnant of lung tissue stitched over stump (Garre).

4. Isolation and temporary clamping of bronchus; curetting of the mucous membrane of the divided bronchus; tight silk ligature; second loose catgut ligature more centrally around bronchus (Friedrich).

Only in rare cases should the pulmonary stump be ligated *en masse;* probably only when the most expeditious work is necessary should this be done. The bronchus, blood-vessels and nerves should be ligated separately. Meyer suggests that the lung be pulled forward with the left hand and its main bronchus palpated; with an automatic forceps the space between accompanying vessels and bronchial wall are perforated, one after the other, from the front backward; a silk thread is pushed between the blades of the forceps by the assistant and pulled through by the operator. The vessel is tied close to the heart. Then by pulling on the first ligature a second silk thread is passed through and tied distally. The vessel is then divided. This manner of securing the vessels in the depth of the thoracic cavity is preferable. It also insures a permanent air-tight closure of the bronchial stump, which is so important. Leakage of any of the channels of the stump would necessitate reopening the chest immediately that it may be arrested.

The fibrous sheath of all stumps should always be included in the ligature surrounding the bronchus, which may or may not be invaginated within itself or the tissues surrounding it, and the length of the stump should be amicable.

INDICATIONS FOR PNEUMONECTOMY, HERNIA, GANGRENE, NEOPLASMS, LACERATIONS.

Hernia or *Pneumocele.* (See chapter on Hernia, Ricketts, "Surgery of the Heart and Lungs," pp. 390-396, 1904.)

Strangulation of the lung has been recognized for several centuries. Among the first to remove the protruding mass was Rolandus, 1499. The patient sur-

vived the ordeal, but there is no record to show that such an operation was again attempted for four hundred years. Since then several such cases have been subjected to successful amputation or reduction.

Hernia may be congenital, acquired, reducible or non-reducible, and vary in size, location, extent consequences and constriction about it. The protruding portion may be returned or amputated without entering the pleural cavity, which minimizes the dangers, but if this cavity be opened they are much more serious. Hernia through the diaphragm is infrequent, but when present reduction is necessary through the abdominal and thoracic cavity.

Gangrene (see chapter on Gangrene, Ricketts, "Surgery of the Heart and Lungs, pp. 375-378, 1904) is circumscribed or diffused, with a downward course along the lymphatics which terminate in the bronchial glands at the root of the lungs, and is most frequently located in the posterior aspect of the upper portion of the lower lobe (Learee). Its most frequent causes are syphilis, abscess, foreign bodies, acute inflammatory diseases and injuries.

In either event it is sometimes necessary to excise more or less of the diseased tissue, all of which absolutely necessitates drainage by gravity, if the patient is recumbent or semi-recumbent. The mortality is exceedingly high, and convalescence greatly prolonged.

Technique.— Incarcerated and gangrenous portions of the lung should be amputated before any attempt to reduce them, and the stump left permanently fixed in the thoracic or diaphragmatic wall with drainage, though it may be securely sutured after bleeding vessels have been ligated and covered with the neighboring overlying cutaneous or other structures. When not incarcerated or infected, and of recent date, an attempt with reasonable degree of force may be made to return the herniated portion to the pleural cavity; when unsuccessful the constricting tissues may be divided, or if necessary the bone or cartilage or both may be exsected or remain in the form of osteoplastic flap.

If, however, gangrene exists without hernia, the chest should be opened over the affected area, the

pathology removed, blood-vessels ligated, pleural cavity freed from fluid and débris, and firmly packed with gauze for drainage and to prevent expansion of the lung. If the greater portion of one or more lobes is involved, no attempt should be made to remove all of the diseased area. Indeed, in many of such cases no attempt at resection of the lung should be made, only thoracotomy and drainage should be done. Should secondary hemorrhage ensue, a large osteoplastic flap should be resorted to, that forceps may be applied to the bleeding vessels, or, if necessary, to the bronchus and vessels supplying the affected lobe or lobes. Styptics, such as water heated to the degree of tolerance, adrenalin and alcohol, may be freely employed for styptic and irrigating purposes. Drainage should be ample throughout the course of recovery, and great caution maintained to prevent pneumothorax, which may be sudden or slow in its development.

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Neoplasms when non-malignant usually necessitate removal, with or without infection. If not infected, the wound for such a purpose may become so at any time, so that drainage is important in the after-care.

Twenty-Six Cases of Cancer in the Chest.—"Operative removal was not attempted in any case. Three of the cancers were in children between five and twelve, and three others between the ages of thirty and forty. Among the seventeen primary tumors all were sarcomas except one, and five of the nine secondary cancers. The duration of the affection after the first symptoms was less than six weeks in all the primary cases; the secondary cancers usually proved

fatal in one or two months. The temperature was normal throughout in nine of the twenty-six cases. Cancers of the esophagus are not included in this review. Seven of the seventeen primary and one of the nine secondary cancers were in well-to-do patients. In one five-year-old boy a mediastinal sarcoma with an acute onset ran its course in five weeks after a trauma, but a cough had been observed a week before the latter. In another case a widow of forty-two noticed the first symptoms of a secondary malignant pleuritis three weeks after a blow on the back. Among the twelve cases with autopsy there were two primary sarcomas in the pleura, three in the lungs, three in the mediastinum and three in the thymus, with one primary carcinoma in the mediastinum. The abdominal organs were the seat of metastases in nearly every case, especially the liver. In the nine secondary cases with autopsy, the primary cancer was in the ovary, testicle or breast."

Technique.—Though the method for removing malignant and non-malignant is practically the same, the end-results greatly differ. Malignant neoplasms of the lung are seldom if ever amenable to surgery, while those non-malignant offer every hope for permanent recovery. Therefore, the removal of a malignant growth in the lung may be seriously questioned, unless early, when difficult to detect without opening the chest.

Without adhesions one or all lobes of one lung may be brought from within the thoracic cavity sufficiently well to excise a neoplasm involving a part or all of one or more lobes, with knife or cautery, preferably knife. All blood-vessels and bronchi should be ligated with non-absorbable material corresponding in size with the vessels and bronchi which they are to surround.

The walls of the divided lung should be brought in apposition by means of fine non-absorbable material carried by a needle correspondingly small, and inserted about one-half inch from either border and about one-quarter of an inch distant between sutures.

Drainage is essential in all cases of infection and

those attended by much serous effusion. It is probably best to provide for drainage in all non-infected cases, though the wound in the thoracic wall may be permanently closed at the expiration of twenty-four hours.

A pulmonary emphysema is characterized by over-distension of the lung, especially during inspiration. Dyspnea results. Freund concluded that more thoracic space was needed laterally to relieve the over-distention of the lung, especially during inspiration. near the sternum to accomplish it, and did so with most gratifying results.

Various other ingeniously devised operations upon the cartilaginous and bony structures of the thorax have also been done for this purpose with excellent results, some of which have remained permanent.

Emphysema (technique).—Incisions in the neck and thorax to palliate, and low tracheotomy tube introduced below the bronchial rent as a radical measure. Freund divided costal cartilages near the sternum, that they might be lifted in inspiration, because the lung when over-distended in such a condition does not contract on expiration; several cartilages may be divided on either side, but without opening the pleural cavity. Seidele and Goodman have collected twelve cases operated upon in this manner which were more or less benefited; six were permanent so far as dyspnea and cyanosis were concerned.

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PNEUMONORRAPHY.

Suture of the lung has recently become a rational surgical procedure, to close wounds of any character. It is done with fine silk or linen and a round-pointed needle placed well beyond the margin of the wound and deep in the tissue, for the sake of safety and to shorten the time for repair. Without complications the primary dressing need not be disturbed.

Garre suggests closing wounds of the lung by direct suture, prefering fine silk or linen for suture, done by the inverted or penetrating method.

(See chapter on Ligatures and Sutures, Ricketts, "Surgery of the Heart and Lungs," pp. 300-307, 1904).

Stumps of lung tissue should be sutured, not ligated, because they are not so well cared for by nature in the pleural as in the peritoneal cavity.

Technique.—See technique for neoplasms.

INDICATIONS FOR PNEUMONORRHAPHY — LACERATION, INCISION, PUNCTURE, RUPTURE.

Lacerations may be due to injury of various kinds, with or without much destruction to the bony chest. If the chest is opened by the injury, suture is the most certain means of repair, and without complication requires but little attention.

Incisions of the lung may be surgical or traumatic, single or multiple, vary in degree and locality, simple or complicated, with or without much trauma to the chest, and may not correspond to the opening in the chest. They may or may not be infected, and do not always necessitate suture. Drainage is usually essential, and the length of time for convalescence very considerable.

Puncture may be traumatic or surgical, single or multiple, of any shape, degree or depth, and with or without primary infection. Unless serious symptoms develop, indicating hemorrhage, the wound should be treated in a simple aseptic manner; but if infection manifests itself with pus, then the case becomes com-

plicated, and must be dealt with with reference to drainage and perfect after-drainage.

Treatment of Severe Bullet Wounds of the Lung by Suture (Zur Behandlung schweren Schussverletzungen der Lunge mit Naht), M. Grasman, Munich. *Münch. med. Woch.*, October 12, 1909.

Garre's statistics, comprising seven hundred shot, puncture or rupture wounds of the lung, show a mortality of over 40 per cent. by conservative treatment. The reason for this extreme conservatism has been the poor condition of patients when first seen, the exaggerated fear of complete pneumothorax (operative), and the, at times, complete recovery of seemingly desperate cases. The early dangers are internal hemorrhage and asphyxia from pressure-pneumothorax, and the later danger of infection and sepsis. The practice has existed of only at a late stage relieving the pneumo- or hemothorax by puncture. When infection takes place, extensive thoracoplastics have been required. In either case convalescence is protracted, intercurrent dangers are great, and permanent damage to the thoracic organs remain."

"The operation immediately after an injury is short in duration and can, if necessary, be done under local anesthesia. Simple pneumothorax will rarely require interference. Injury to a bronchus, which is followed by pressure pneumothorax (displacement of mediastinum and kinking of the great vessels) demands operation. If uncomplicated, permanent drainage with a valve canula may suffice.

"At operation the thorax should be widely opened, the lung wound found and sutured, all blood within the pleura removed, and expansion of the lung favored by fixation in the wound or by means of the positive or negative pressure apparatus."

The author favors chloroform narcosis. "One or more ribs are resected or a movable flap made. The lung is at once pulled out of the wound; this serves to fix the mediastinum. Both entry and exit wounds are sought for, the edges cleaned or excised, tissues approximated with one or two tension sutures, and a superficial pleural suture inserted (visceral pleura).

Silk should be used. Broad surface wounds are fixed in the thoracic wound. The pleura is carefully cleansed, the lung expanded as explained before, and the costal wound completely closed without drainage. The reported cases of operative interference is now eighteen. Of nine bullet wounds, six recovered; of six puncture wounds, five recovered; of three ruptures, two recovered. Twenty-five additional cases of puncture wounds have been reported with nine fatalities."

The author reports two cases of revolver wounds of the lung upon which he operated by the technique indicated. Both recovered, convalescence proving smooth. One of his cases had an injury of the pericardium in addition to the lung injury.

Kuttler employs fine silk for lung suture, believing that catgut is not flexible enough.

Rupture may be due to injury, and varies in degree and locality; simple or complicated, and may or may not require any surgical interference. It is seldom necessary to open the chest to repair rupture, unless serious complications arise. But if the chest is already opened, it may be repaired with suture and drainage. Rupture of the lung sometimes occurs without laceration or fracture of the bony chest; then the semi-recumbent posture should be assumed, with quietude and opiates given to prevent coughing. Unless hemothorax occurs, there is seldom any necessity for thoracotomy.

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PNEUMONOPEXY.

Pneumonopexy sometimes becomes necessary with hernia to make safe what might otherwise be a serious operation, at the same time does not interfere with function of the lungs. Sometimes the visceral and costal pleura have already become united, and when so, complications are minimized.

INDICATIONS FOR PNEUMONOPEXY—DRAINAGE, HERNIA, INJURY.

Drainage is best accomplished after a cyst wall of the lung has become fixed to the thoracic wall, artificially or by natural adhesion. Drainage may be perfect without any possibility of infecting the pleural cavity when adhesions are well formed, but the duration of convalescence in such cases is considerable, because it must be continuous until the cavity is obliterated by granulation.

Hernia sometimes necessitates fixation of the lung to the thoracic wall after the herniated portion of a reducible hernia has been amputated. This may be done with or without the removal of ribs or cartilages, and seldom requires drainage. Hernia with adhesions may be amputated without additional fixation by suture.

HERNIA.

Injury of the lung may sometimes be cared for more safely when it is made fast to the thoracic wall. This is especially desirable when the lung is lacerated beyond repair by suture, and when there is grave doubt

about the presence of infection, recurrence of hemorrhage, or when it is necessary to expedite the work.

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SUTURE.

Post-operative Lung Complications.—Pasteur concludes his article by stating that he has endeavored to prove that deflation of the pulmonary bases, resulting from reflex inhibition of diaphragmatic movement, is an essential, if not the chief, factor in the causation of post-operative pneumonia, and that the rôle of the anesthetic is only a secondary one. These after-effects are far from rare, and, in the present confused state of our knowledge concerning them, mistaken diagnoses are probably of frequent occurrence. If we are ever to clear up the complex nature of these accidents and to arrive at a more reasonable classification of post-operative lesions, it is absolutely necessary that the lungs should be carefully examined by a competent observer, and the exact position of the heart-beat noted before every abdominal operation. In this way alone will it be possible to appreciate the slight changes in the breath sounds, in the respiratory movements of the chest, or in the position of the apex beat,

which indicate the onset of trouble, and often give a sure indication of its nature. Pasteur is convinced that a good deal can be done in the way of preventing or alleviating many of these troubles, but before this can be achieved with any hope of success the present slipshod diagnosis of after-effects must be replaced by something more accurate. Abdominal section is a hit below the belt. The patient is always winded by it, more or less, and that is the real reason why abdominal operations are so often followed by lung trouble.

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Gunshot, Stab, Incised Wounds.

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PNEUMONOPEXY.

The after-care of operations upon the lung is similar for all, because either may be primarily aseptic or septic and remain so, or if aseptic they may become septic at any time. If aseptic, drainage may be necessary at first, but may be discontinued at the end of two or three days.

The changing of dressings of aseptic wounds of this character will depend upon the amount of secretion.

If there is primary or secondary infection frequent dressings are necessary, and the free escape of fluids should be made certain at all times. Drainage should be by gravity as far as possible, secured by the semi-sitting posture immediately after the operation.

It is seldom necessary to drain the pleural cavity with pneumonopexies, only occasionally the stump of the lung in the thoracic wall, when aseptic, but always when septic.

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SURGERY OF THE BRONCHUS.

BRONCHOTOMY, BRONCHECTOMY, BRONCHORRHAPHY.

BY B. MERRILL RICKETTS, M.D.,
CINCINNATI.

ANATOMY—SURGICAL.

The bronchi, two in number, right and left, are extensions of the trachea. The right is shorter, greater in diameter and more perpendicular. The right bifurcates to supply air to the two lobes of the right lung. Occasionally this number of tubes may be increased, but when so it is due to congenital defects. When they exist, there may or may not be an increase in the number of lobes in the lungs, because one lobe may be supplied with more than one bronchus. With an anomalous increase of the number of lobes, their size will be diminished, consequently the size of the bronchi will be lessened.

Bronchial arteries arise from the aorta, and supply walls of the bronchi, the pulmonary vessels, the lymphatic glands, and the connective tissue of the respiratory plexus. The corresponding veins empty into the vena azygos and the vena pulmonalis. The venous radicals from the ultimate bronchioles empty into the vena pulmonalis; and the arterial branches into the vena azygos.

Nerve supply is from branches of the phrenic; the the pulmonary plexuses are formed from branches of the vagus and sympatheticus. The filaments of these plexuses follow the ramification of the bronchi and finally become lost on them in the parenchyma of the lungs. They possess but slight sensibility, especially in the smaller branches.

Lymphatics originate in the alveolar septum and communicate directly with the alveolar cavity by stomata in the alveolar walls. They form a plexus in the submucous tissue accompanying the branches of

the bronchi, as well as the pulmonary veins and arteries, emptying finally into the bronchial glands at the roots of the lungs. They may be recognized many times by their gray or black speckled appearance, which is due to absorption of pigment or foreign bodies.

Traction diverticuli have been observed by Innermann (*Deutsch. Arch. f. klin. Med.*, p. 235, 1869) and Tiedemann (*Deutsch. Arch. f. klin. Med.*, vol. xv, 1875). In the first the wheels were at the hilum of the lung, and the mucous membrane pushed out between the first and second rings of the right bronchus, forming a narrow cleft-like opening into a pocket nearly 1 cm. in depth. In one of Tiedemann's cases a diverticulum 3 m.m. in depth extended through the space between the third and fourth cartilages of the left bronchus. In a mass of scar tissue on the outer side of the bronchial tube was found the remains of a calcified shrunken bronchial gland.

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SYMPTOMS.

Diagnosis can usually be made with comparative ease by the use of the X-ray, bronchoscope or sound. Auscultation and percussion are also valuable adjuncts.

Treatment: (1) medical, (2) surgical.

Medical treatment consists of arsenic for papillomata; mercury for syphilis, the X-ray, radium and serum for malignant neoplasms.

Arsenic given gradually until the maximum dose is attained will often cause papillomata to disappear. Sulphate of magnesia, in ten to twenty grain doses three times a day, has also been known to cause them to disappear when found upon the cutaneous and other mucous surfaces, and there is no reason to believe that they will not do so when present upon the respiratory mucous membrane.

Mercury and other anti-syphilitic remedies should

always be administered until the maximum dose is attained before radical surgical measures are resorted to for the removal of bronchial neoplasms. They may be given by the mouth, subcutaneously or directly into the blood current, or by inunctions or baths of various kinds.

Serum offers many inducements for its use in various kinds of neoplasms, so that it may in due time become a valuable adjunct in their treatment.

Roentgen ray has been found to have a specific influence upon certain forms of malignant growths involving the bronchus, but its limitations have not yet been defined; it should, however, be more generally employed until they are better established.

Radium has been found to be a most excellent application to malignant growths involving the trachea and bronchus, when applied directly through the bronchoscope. The technique for accomplishing this is exceedingly difficult, especially because of the length of time for exposure. However, the end justifies the means, and whenever possible it should be employed before radical measures are applied.

SURGICAL TREATMENT.

Surgical treatment constitutes direct removal through the epiglottis with or without the bronchoscope, tracheotomy with or without the bronchoscope, or an incision through the neck or various localities upon the thorax.

Trans-epiglottic surgical measures for the removal of foreign bodies or neoplasms is probably the oldest method in existence, having been done with forceps and various devices in a sort of a "catch-as-catch-can" way because for many years it was done without direct or indirect light. However, the technique has been greatly simplified since it has been made possible to reflect light and introduce the bronchoscope.

Bronchoscope has been the greatest contribution to the surgeons' armamentarium for treating lesions in this locality. It has simplified the work beyond measure and greatly reduced the possibilities for intrathoracic surgery of the bronchus.

Tracheotomy has always been the accepted method

for removing foreign bodies and neoplasms from the trachea and its bifurcation, directly by removal and indirectly by expulsion resulting from explosive coughing. The introduction of tracheal tubes should never be resorted to, in case of failure to extract the foreign body, but if the severed walls of the trachea are kept wide apart by string retractors the foreign body if not imbedded will usually be expelled through the incision. Such an operation may be done with local anesthesia, sometimes without anesthesia of any kind. However, many cases will require pulmonary anesthesia.

Tracheotomy is also valuable for exploration and locating bodies in the right and left bronchus with sounds when the X-ray fails to reveal them.

Trans-cervical incisions to reach and open the upper portions of the trachea is a well established procedure for stricture, foreign bodies and neoplasms in this locality, and, when trans-epiglottic measures have failed, it should be a method of choice before resorting to other more radical measures.

Trans-thoracic indicates such measures as are required to reach the bronchus through the thoracic walls, such as anterior, posterior and lateral thoracotomy; of these, the anterior and posterior routes are considered superior in the order they are given. (For technique, see chapter on mediastinum).

BRONCHOTOMY.

Intra-thoracic incisions of the bronchus have rarely been attempted until recently, and, while successful, the bronchoscope has been so perfected that incisions will probably now be done less frequently. However, there will be cases which will necessitate opening the bronchus through the lung. It is one of the most daring operations in modern surgery, but may now be made less so by one of the methods employed, such as the vacuum chamber or intra-tracheal insufflation.

The bronchus may be injured, contain foreign bodies, neoplasms or fistulæ, which may necessitate suture, removal or incision with or without suture. That any one of these may be accomplished, a thorocotomy and pneumontomy is necessary; not, however, until all at-

tempts to do so with the bronchoscope or tracheotomy have failed.

INDICATIONS FOR BRONCHOTOMY—FOREIGN BODIES, NEOPLASMS, FISTULAE.[1]

Foreign bodies may be detected by the X-ray or a sound introduced through the epiglottis or an opening in the trachea. These are also favored routes for their extraction, with or with out the use of the bronchoscope. But, when the foreign body is large with sharp angles, or when it is deeply embedded in the wall of the bronchus and resists reasonable traction, direct thorocobronchotomy will be preferable.

Symptoms of foreign bodies in the bronchus may be mild or very pronounced. Pain and dry cough are frequently present. Dyspnea, cyanosis, apnea and cardiac failure are occasionally present. Hemoptysis may be absent or present in varying degrees. If the right bronchus is entirely blocked, the right thorax is retracted and dull and the left thorax is distended. Respiratory murmurs are absent in the right thorax. Emil Myer (*Jour. Am. Med. Ass'n.*, Nov. 10, 1906, vol. xlvii, No. 19, pp. 1553-55). When the bronchus is not entirely blocked moist râles may be present or absent.

Diagnosis.—The history of a foreign body having mysteriously disappeared while being carried in the mouth, together with a history of cyanosis and dyspnea and pain, is a very clear history of foreign body in the air passages. If, however, these signs are absent and there is a history of pain beneath the sternum and dry cough, there is also a probability of the foreign body having passed into the bronchus.

Roentgen rays are of use when the foreign body is of such material as will be recorded upon a radiograph.

Bronchoscopy is the most positive means of diagnosis. It should be reserved as the last means of diagnosis in children, because it is often necessary to perform tracheotomy before the bronchoscope can be

1. See Ricketts, "Surgery of Heart and Lungs," pp. 341-358, 402-408, 1904.

introduced into the bronchus successfully; when bronchoscopy is resorted to, however, the foreign body may be removed during the examination.

FOREIGN BODIES.

Foreign bodies which find their way into the bronchus are liquids and solids.

Liquids may be inspired during vomiting of anesthesia, alcoholism or unconsciousness from other causes; not only liquids but solid articles of food may be present under such circumstances.

In drowning, water is inspired into the bronchus and bronchi.

Solid bodies which have been removed from the bronchus are hard, soft, smooth and irregular. They may be soluble or insoluble. Candy is one of the soluble articles; such insoluble articles as tacks, pins, needles, nails, bones, toys, rubber erasers, buttons, coins, cereals, tracheotomy tubes, calculi, etc., have been extracted from the bronchus. When cereals, such as corn, peas and beans are lodged within the bronchus, especially the bronchi, because of their affinity for moisture they expand and finally disintegrate. It is apparent that it is easier to remove such bodies soon after their lodgment.

Usually the right bronchus is the recipient of foreign bodies, because of its larger size and obtuse angle. Shawl pins have transfixed the bronchus, while rough and sharp ones have lacerated and incised it.

Complications depend upon the size or sharpness, whether or not it becomes disintegrated, and upon the kind of bacteria in the lung or upon the foreign body. Bronchitis, pneumonia, fistula, gangrene and abscess of the lung may result.

Treatment.—Soluble foreign bodies do not need to be removed because of their solubility.

Irritation of the larynx has caused coughing and expulsion of the foreign body.

Tracheotomy has been performed to remove foreign bodies from the bronchus; when this is done a blunt-hook forceps or magnet may be used.

The bronchoscope is an instrument of comparative

recent date. Rosenhime passed the esophagoscope into the bronchus by accident. (Ref. Kristina, *Berl. Klin. Wochenschr.*, No. 22, June 3, 1895). In 1897, Killian removed the first foreign body. (Ref. Kollofrath, *Muench. Med. Wochenschr.*, No. 38, Sept. 21, 1898) In children it is often necessary, because of the difficulty of introducing the bronchoscope, to perform tracheotomy. The bronchoscope can then be passed into the bronchus through the tracheal wound and the foreign body removed with forceps, blunt hooks or magnet, if the substance is metallic. When the foreign bodies have transfixed the bronchus they may be cut in two with Casselberry's forceps and the pieces removed. (W. E. Casselberry, Chicago, *Jour. Am. Med. Ass'n.*, July 2, 1910, page 9).

Impacted foreign bodies may be very difficult to remove. Indeed it may be necessary to do bronchotomy in such cases.

Johnston (*New York Med. Jour.*, vol. lvii, No. 2) refers to a new method of passing the bronchoscope which has made bronchoscopy much easier for him. The difficult stage of bronchoscopy is in passing the tube between the vocal cords into the trachea. The vocal cords once passed, it requires no special skill to push the tube further down. He conceived the idea of placing the patient's head straight on the table and passing the old Jackson laryngoscope down between the incisor teeth. The epiglottis was pulled up and a clear view of the larynx obtained. In his earlier work, he placed a pillow under the head to secure flexion. Further observation has convinced him that flexion is not necessary; a straight position of the head, held firmly by an assistant, makes direct laryngoscopy easy. After working with the straight method of laryngoscopy for some time, it occurred to him that it might be feasible to pass the bronchoscope in this position, thus eliminating the strain on the wrist and the force required to overcome the tense muscles in the extended position. It has worked admirably and proved easy.

The patient is placed on the table with the head in a straight normal position. A general anesthetic is administered. The modified direct laryngoscope is passed

straight down between the incisor teeth, and when the epiglottis comes into view the spatula end of the instrument is hooked behind it. By making slight pressure on the upper teeth the epiglottis and base of the tongue are pulled up and the larynx opened for inspection. A weak solution of cocaine is now applied to the larynx through the tube to prevent reflexes. With the laryngoscope in position, the bronchoscope is passed through it to the vocal chords. With the eye fixed on the end of the smaller tube, a slight twisting motion is used, which sends the bronchoscope between the cords. The breathing is now distinctly tubal in character. The laryngoscope is removed and the head of the patient gently lowered over the end of the table. The examination is now proceeded with as in the extended position.

In the above procedure the operator stands to the left of the patient and uses the laryngoscope in the left hand. Both direct laryngoscopy and bronchoscopy are easier because the muscles are relaxed.

Post-Operative Treatment.—Menthol camphor and oil of eucalyptus dissolved in liq. petrolati may be injected into the trachea as antiseptics. Dr. J. A. Thompson has reported cases where streptococcus and staphylococcus infections were benefited by intratracheal injections. If this be true, such injections would be of value after the removal of foreign bodies. If bronchitis or pneumonia exists or arises as a complication, then the usual treatment should be given.

Drowning.— Water having entered the lungs through the epiglottis may reasonably be classed with foreign bodies of the bronchus. There is no foreign body in the bronchus the removal of which is accompanied by better results than water, none more easily to accomplish before or after cessation of the heartbeat. Resuscitation has been successfully accomplished after the heart had ceased to beat for more than two hours in case of suffocation due to the presence of water in the lungs.

Several crude methods have been devised for this purpose, namely, perpendicular suspension with the head low; manipulating the body upon a log, box or

barrel; mouth-to-mouth breathing, and compression of the thorax while the abdominal viscera is forced upon the diaphragm. The more scientific methods are surgical, intra-thoracic and extra-thoracic.

Intra-thoracic include methods of operations that are done within the thoracic cavity through an opening in the thoracic wall (thoraco-pneumono-bronchotomy). After suturing the lung to the thoracic wall, an incision is made through the lung into the bronchus, into which a rubber catheter is inserted and the water drawn from the lung with the mouth or a syringe. Such a procedure will seldom if ever be necessary, but it is a surgical possibility that may be taken advantage of when the proper time, place, opportunity and operator are available.

Extra-thoracic pertains to those methods in which it is not necessary to enter the thoracic cavity, such as tracheotomy and trans-epiglottic.

Tracheotomy is a very desirable method for draining water from the tracheo-bronchial tree. It may be done by gravity, the mouth or syringe, through a rubber catheter introduced into the right and left bronchus. The opening into the trachea should be maintained indefinitely, or at least several hours after resuscitation has been complete.

Trans-epiglottic includes all methods that are executed through the epiglottis. This has now been made the method of choice, especially when the advantages of drainage and insufflation are combined. The introduction of a catheter open at the distal end (not a lateral opening) may be easily accomplished by the inexperienced, and drainage made perfect with ease.

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Neoplasms, except polyps, so far as known, have not been removed from either bronchus; but now that the bronchoscope, intra-tracheal insufflation and vacuum chamber have added so much to the surgeon's armamentarium, many of them can be excised with safety.

Neoplasm of Bronchus.—Laennec wrote in 1827 of finding only three cases of neoplasms of the bronchus on record. His references are: Murry nov. Comm. Goetting. iv. 44; Cheyne, Ed. Med. and Surg. Jour., iv; Horn. Archiv, 1811, Jan., p. 176; Laennec, p. 131, "A Treatise of Diseases of the Chest and Mediate Auscultation," translated by John Forbes.

Polypi.—Their early history begins with Clark, 1700. Since then many such cases have been reported Hearn and Roe, 1901, record a case of pneumotomy for abscess of the lung due to a polypus extending into it. It is therefore assumed that the bronchial polypi, when large, may be the subject for surgical consideration other than with the bronchoscope.

Fistulæ are not commonly found in the bronchus, though they do occur. Such a condition was discovered by B. F. Lyle in an adult male who had suffered with a tubercular abscess in the left lung. Air and mucus escaped periodically through an opening in the external soft structures overlying the sixth intercostal space, one inch to the left of the nipple.

Bismuth paste, when injected into fistulous tracts, will sometimes cause them to become permanently closed. The proportions are, one of subnitrate of bismuth to three of vaseline, well triturated. Only a small amount is necessary. Two or three drachms injected once or twice a week for several weeks will

usually be sufficient in the absence of foreign bodies or diseased bone.

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BRONCHECTOMY.

Bronchectomy.—Records do not show that any portion of the bronchus has been removed in experimental or applied surgery without loss of lung function. However, it is logical to suppose that anastomosis of the bronchi with preservation of lung function is a possibility, especially when small segments have been excised for injury or disease or severed transversely

with the knife, stilletto or projectiles from firearms. If function is not restored, atrophy of the lung ensues, though the function of the alveola may be restored after many months of quiescence. In such a case, when necessary, an attempt to anastomose the bronchi might be justifiable.

BRONCHORRHAPHY.

Suturing the bronchus is no longer a mooted question, it having been done successfully in a few instances experimentally upon animals and upon man. It is done with absorbable suture material, and of necessity through an opening in the chest wall and lung tissue. Its limitations are not great, but its necessity frequent enough to demand consideration. Drainage is necessary, and enforced quietude essential in the after-care.

Bronchial segments devoid of cartilage may be easily and safely secured by ligature, but when they contain cartilage any method is more or less unreliable.

INDICATIONS FOR BRONCHORRHAPHY.—RUPTURE, LACERATIONS, INCISIONS, PUNCTURE.

Rupture of the bronchus is not infrequent, and it may be due to foreign body, neoplasm, injury, parasites or pathologic organisms in any of the intra-thoracic tissues, usually infected, and may require suture, that the best interest of the patient may be conserved.

Aneurism is the most common pathologic condition in which perforation of the bronchus occurs.

Lacerations are infrequent, and generally due to foreign bodies from within or violence from without, and as a rule, like rupture, should be sutured, especially when extensive.

Incisions may be oblique, longitudinal or transverse, and due to violence or surgical repair. They are most favorable for suture, which must necessarily be done through the lung with absorbable material.

Puncture may be large or small; in the right or left bronchus or both; smooth or irregular; single or multiple; from without or within the bronchus, and probably always infected.

Technique.—Thoracotomy having been performed, the bronchus may be exposed by several routes. In the anterior median line the tracheo-bronchial portion may be well exposed without incising any tissue other than the delicate cellular tissue immediately in front. When the lateral or posterior routes are resorted to it will be necessary to incise the lung to reach the bronchi for the purpose of removing foreign bodies or neoplasms; but when the lung has been already injured it will probably be better to follow the original course of the wound, though that will not always be necessary. A short, heavy-curved needle, carrying fine silk or catgut of equal strength and duration, may be inserted with or without interruption. However, the rule of suture does not obtain, because, experimentally, wounds of the bronchi have closed permanently without suture and without complications. This has also occurred in a few cases in the human being. Drainage should be the rule.

BRONCHOSCOPY.

The after-treatment of incising and suturing the bronchus for any purpose is the same, whether aseptic or septic, with or without drainage. It is said that such wounds are always septic, but some have been known to unite primarily without infection or drainage. Some such incisions have united under these circumstances without suture.

If primarily aseptic and if they remain so, the dressings need not be disturbed until the seventh or eighth day, when union will have been found to be complete. Any sutures in the cutaneous structures may be removed at the end of this time. The reclining position should be maintained until after the tenth day, and violent or sudden motion of the body should be prevented with narcotics if necessary.

BRONCHIECTASIS.

Bronchiectasis results from bronchitis or emphysema, and is of two types, cylindrical and saccular. Paroxysmal cough, especially immediately after rising from recumbency, with an excessive amount of expec-

toration, pus in character, sometimes becoming fetid, are indications.

Treatment is medical and surgical. Medical treatment is of but little, if any, avail.

Technique.—Artificial pneumothorax may be resorted to as the first of all surgical procedures, by means of hydrogen gas or normal saline solutions, for the purpose of evacuating the pus cavity by pressure, absorption or location after thoracotomy. If located, incision and drainage should be done with or without viscero-costal adhesions. Korte records fifteen cases operated on with eleven immediate deaths.

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SURGERY OF THE PERICARDIUM.*

PERICARDIOTOMY, PERICARDECTOMY, PERICARDIORRHOPHY.

BY BENJAMIN MERRILL RICKETTS, M.D.,
CINCINNATI.

Anatomy.— The pericardium is conical in shape, lined with serous membrane, composed of fibrous tissue, and rests on the central tendon of the diaphragm. Anteriorly it is attached above and below to the sternum, while posteriorly are to be found the bronchi, the esophagus and thoracic aorta. The pericardial cavity can be made to contain about fourteen ounces of fluid. while the normal amount is but two or three ounces Sometimes an excess of fluid in this cavity will cause loss of voice from pressure.

The pericardium may be injured or diseased to such an extent that suture, incision or partial excision may become necessary. Either one or both of these may be necessary when not injured or diseased, that exploration of its contents or operations upon the heart may be done. To do these, the sternum should be trephined or costal cartilages removed.

Experimental surgery of the pericardium has shown that it may be considered from a practical point of view. It may be incised, sutured and excised in part or in its entirety with safety, both in health and disease.

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Diagnosis and Differential Diagnosis (Calvert).—"In *dilatation* of the right heart the liver is actually depressed as measured by vertebræ, but apparently elevated as measured by ribs. As this changed relationship with the liver apparently depends on the same principles as the normal relationship of the liver, it is reasonable to assume that the apparent elevation (with respect to the ribs) of the liver in dilatation of the right heart is constant; or a provisional general statement may be made as follows: Dilatation of the right heart actually depresses the liver; the left lobe of the liver is depressed more than the right, producing a high cupolated right lobe; right lobe of liver due to depression of the ribs is higher than normal, apparent elevation; the degree of change in the form and position of the liver depends on the degree of dilatation of the right heart. Or the movement of the liver is marked by pathologic enlargement of the right heart, and seems to be a continuation of the normal movement occurring in the development of the fetus to maturity.

"In *pericarditis* with effusion, different physical forces are at work. Here the heart and venæ cavæ are compressed by the pericardial pressure, and cannot dilate to the same degree as they do in the absence of pericardial pressure. The dilatation of the heart in pericarditis with effusion is most probably in many cases a post-mortem phenomenon, developing as the autopsy progresses, and due to the congestion of blood in the large veins and lungs flowing into the heart as the pericardial pressure is removed. To be sure, the myocarditis present in pericarditis favors dilatation, especially if the pericardial pressure is low, owing to weak pericardial walls. Again, the heart may be dilated before the effusion developed. In general, the physical forces in pericarditis tend to keep the heart at the same size as it was when the effusion began to develop, or at a diminished size. The inferior cava remains in its normal position, or may be pushed to the left by the descent of the liver. The dilating pericar-

dium extends to the right over the diaphragm a distance depending on the degree of dilatation, and the intraperitoneal pressure tends to push the liver down. The degree of displacement of the liver depends of course on the degree of pericardial pressure. Here the liver has only its normal support.

"*The inferior cava* remains near the median line in a posterior position. Consequently the right lobe of the liver is deprived of its support. In pericarditis with effusion, the right lobe of the liver is displaced downward approximately the same distance as the left lobe (without the apparent elevation as in cardiac dilatation). The right and left lobes of the liver are more nearly on a level, or tend to assume the position found during fetal life. The sternum and ribs descend relatively the same distance as the liver. Here the liver is actually lower without the apparent elevation.

"A provisional general statement may be made as follows: Pericarditis with effusion tends to produce (or actually does produce) the following conditions: Diminution in the size of the right heart; actual depression of the liver without apparent elevation of the right lobe, so that the right and left lobes are more nearly in the same plane; displacement of the inferior cava to the left with its convexity to the left. Or, in pericarditis with effusion the relationship of the right heart and liver tends to revert to that found in fetal life.

"It is thus seen that in the two conditions diametrically opposite physical forces are at work, the cardiac dilatation tending to produce a relatively high position, the pericardial effusion a low position of the right lobe of the liver. A difference of as much as two or more interspaces in the position of the right lobe of the liver may occur.

"Naturally the variation in the position of the normal liver is of importance. In the literature reviewed it seems that much of the material on which present statistics of the normal position of the liver is based is pathologic, and that the subject needs reworking with the pathologic positions of the liver and the type of thorax constantly in mind.

"*In cardiac dilatation* the root of the right lung re-

mains at about its normal level as compared to the vertebral column. When the right dilates, the lower anterior portion of the right lung is lifted upward, outward and backward. The downward displacement of the right lung gives an apparent elevation to the right lung. There is, then, an actual and an apparent elevation of the lower anterior portion of the right lung.

"*In pericarditis with effusion*, owing to the small left auricle, the root of the right lung is not displaced to a degree corresponding to that in dilatation. The lower anterior portion of the right lung is not lifted as in dilatation, but pushed by the pericardial sac outward and backward. The downward displacement of the ribs gives an apparent elevation (if pleuræ are adherent, the lung follows the ribs).

"In cardiac dilatation the real elevation of the lower anterior portion of the lung border serves to diminish the area of lung-liver relative dullness. The degree of narrowing of this area varies from what might be called a diminished area to almost complete absence of relative dullness. The relative elevation of the liver places this area of dullness high—fourth rib.

"In pericardial effusion the liver is pushed down proportionately more than the lower border of the lung is elevated, so that the area of lung-liver relative dullness is narrowed or obliterated, and occupies a lower position than it does in cardiac dilatation. If the pericardial pressure is sufficient to push the sternum and ribs down, the liver is also pushed farther down, and consequently does not alter the relationship as described. Or, the differential sign should be, in cardiac dilatation a high liver with a diminished area of lung-liver relative dullness, fourth rib; in pericardial effusion, a low liver with a diminished area of lung-liver relative dullness, sixth rib.

"*The differential sign* is composed of two factors, the position of the liver and the presence and position of a diminished area of lung-liver dullness. Of these, the position of the liver is most important, for the reason that it is more easily deflected in corpulent patients, in whom the lung-liver relative dullness is more important than the fact that it is narrow. As the po-

sition of the relative dullness depends on the same forces which displace the liver, the absence of or failure to find the relative dullness should not materially detract from the value of the sign. Owing to the physical forces causing the change in the lung-liver relative dullness, this area must vary from a diminished area to an area of dullness too narrow for detection.

"In cases of moderate cardiac dilatation and pericarditis with effusion, the changes in the position of the liver and the lung-liver relative dullness cannot be developed to a degree sufficient for a clinical sign. But as the physical forces at play are essentially different in kind and effect, these forces should develop in advanced cases a displacement of the liver sufficiently well marked to constitute a differential sign. As this sign becomes more and more marked as the lesions develop, it reaches its greatest development at a time when differential diagnosis is most difficult."

INDICATIONS FOR PERICARDIOTOMY—BLOOD, PUS, SERUM, FOREIGN BODIES, NEOPLASMS.

Blood in small quantities should usually remain undisturbed, but it sometimes becomes necessary to remove large amounts, and this should be done under most rigid aseptic precautions, through an incision made in the pericardium after trephining the sternum, or by an osteoplastic flap, including the ribs and costal cartilages.

Pus of any character should be removed as soon as detected, by trocar or open incision, preferably incision at the lowest possible point, that drainage may be made more perfect by gravity.

Serum, unless in amounts sufficient to cause cardiac disturbances, should not be removed, but when these exist, it is preferable to remove it by trocar at intervals sufficient to overcome its effects, until the amount secreted becomes normal. Each operation should be done under most rigid aseptic technique, and without complications need not necessitate any great care.

Foreign bodies require opening of the pericardium for their removal. Usually, when not complicated be-

fore removal, the incised walls may be immediately coapted with suture without drainage.

Neoplasms when pedunculated are easily removed by ligature or excision, with suture at their base. In the absence of any complications the after-care is simple.

Technique.—Pericardiotomy is done with a trocar or knife, through an opening made by trephining the sternum, or after one or more ribs or costal cartilages have been removed. Care should be exercised to prevent injury to the heart, and the opening made at or near the floor of the pericardial sac, for gravity drainage. It may also be done through the pleural cavity, especially when it has already been opened. With a large opening in the pleural cavity, the work will probably be more satisfactory when done by intra-tracheal insufflation or in the positive pressure chamber. With opening the pericardium, drainage is an important factor as a rule, probably more frequent when the pleura has been opened.

It is best accomplished after one of the costal cartilages has been removed, especially when it is necessary to secure drainage by means of gauze, tape or rubber. Either of these may be introduced through an incision in the fifth or sixth intercostal space close to the left border of the sternum, though these intercostal spaces are very narrow. The fifth, sixth and seventh costal cartilages may be divided immediately to the left of the median line, and the pericardial cavity entered without injury to the pleura.

It is difficult to introduce a needle into the pericardial space without entering that of the pleura, unless the needle is passed through an opening in the sternum, so slight is the attachment of the pericardium with the chest wall. However, this space is increased in width when the pericardium is distended, because the lung and pleura are carried upward and downward with it.

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PERICARDECTOMY.

In *pericardectomy* portions of the pericardium, especially the anterior and lateral walls, may be excised, and when not too large the incised edges may be successfully sutured. The entire anterior and lateral walls have been removed from the dog by circumcision without fatality. It is probable, however, that the adhesions which must necessarily result from such trauma will in due time produce serious, if not fatal, compression of the heart and its immediate vessels.

The *indications for pericardectomy* are cysts, neoplasms and gangrene, primarily or secondarily involving the sac, and when cardiac function is disturbed by compression resulting from thickened walls due to inflammation or abnormalities.

PERICARDIORRHAPHY.

Pericardiorrhaphy is required when openings are large and sometimes when the wound has been made so for drainage at the lowest point in the sac. If the pleural cavity has not been entered it is always necessary to remove ribs, sternum or costal cartilages, and when not complicated occasions but little after-care.

Sutures may be applied through the pleural space when it has been opened, but, with such a case, drainage of that space may be necessary.

INDICATIONS FOR PERICARDIORRHAPHY —PUNCTURES, INCISIONS, LACERATIONS, RUPTURES.

Punctures may be of little consequence, or of great importance, depending upon hemorrhage or infection or both. If the wound be enlarged for perfect drainage, there is but little attention necessary in the absence of complications.

Incisions, accidental or intentional, many times require suture without drainage, but it is necessary to sever ribs or cartilages to do it, and when without in-

fection usually terminates favorably with but little trouble.

Lacerations are irregular in shape and should be sutured at once. If necessary, cartilages and ribs should be removed to do it. Drainage is necessary, because the clots are usually infected; such cases are always more or less complicated.

Rupture may be into the subcutaneous tissue, pleural or mediastinal spaces, either one of which may necessitate closure by suture, and, unless infection follows, the after-care is simple.

Technique.—Through an ample opening in the left thoracic wall must all sutures be applied. Sometimes the smaller wounds may be delivered externally, but only when they are in the anterior lower portion of the pericardium can this be done. After freeing the cavity of clots and foreign bodies, interrupted sutures of catgut, silk or linen preferably, the non-absorbable material, are placed about one-quarter of an inch apart, leaving a small opening in the lower end of the wound for tape drainage. The pleural cavity, if exposed, is then cleansed and the chest wall closed, with the exception of a point of exit for the tape.

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The after-care for incising and suturing the pericardium is the same, and aseptic dressings secured by means of a muslin jacket or adhesive plaster are all that will be necessary. If septic with drainage the dressings must be changed frequently and the cavity drainage kept free. The reclining position should be assumed in drainage cases as soon as possible, that the escape of the secretions may be more certain and constant until it ceases permanently.

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CHAPTER XI.

SURGERY OF THE HEART.*

CARDIOTOMY—CARDIORRHAPHY.

(See Ricketts' "Surgery of the Heart and Lung," Chap. 5, Gunshot, Lacerated and Incised Wounds, pp. 91-120, 1904.)

Experimental surgery of the heart has not reached its zenith, though many remarkable feats have been accomplished, both experimentally and applied. Intracardiac surgery for foreign bodies, neoplasms and diseased and injured valves remains a possibility, with every hope that it will become established with general well-founded principles.

THE FETAL CIRCULATION.

The chief peculiarities of the fetal circulation are the *foramen ovale,* the ductus arteriosus and the ductus venosus. They modify the course of the blood to such an extent that the better quality of blood goes to the head and upper extremities, thus partly at least accounting for the greater size and development of the upper portion of the body. These peculiarities are better understood if we remember that the veins carry oxidulated blood from the placenta to the fetus (a reversed circulation), and when we follow it through its course from the umbilicus through the fetus back to the umbilical cord. The circulation may be arranged schematically as follows:

Umbilical vein to the liver; liver, by the hepatic veins and the ductus venosus, to the inferior vena cava, to the right auricle, to the left auricle, to the left ventricle, to the aorta, to the head and arms, to the superior vena cava, to the right auricle, to the right ventricle, to the pulmonary artery, to the ductus

*An illustrated lecture delivered to the students of the American Medical College, St. Louis, Mo., March 16, 1911.

arteriosus (very little through the lungs and back to the left auricle by the pulmonary veins), to the descending aorta, to the hypogastric arteries, to the umbilical cord (major portion), and to the pelvis and lower limbs (minor portion), from where it is returned to the inferior vena cava. (Deaver.)

Patency of the foramen ovale.—This opening between the two hearts, and so necessary to fetal life, should close within fifteen days after birth, but it frequently fails to do so.

The cause of this is due to any condition of the heart or any of its valves that obstructs the normal flow of blood through them.

Narrowing of the conus, on either side, inequality of the blood pressure in the two auricles, obstruction of the pulmonary artery and stenosis of the auriculo-ventricular orifices are the most common causes for patency of this foramen, which may vary in size from one-twentieth to three-eighths of an inch.

Failure to ever close completely and the subject live to advanced old age is probably quite common, because a mixed blood established in utero does not necessarily shorten or destroy life.

Many of the lower animals normally possess mixed blood, thus evidencing the fact that the body tissues may gradually become adjusted to such change.

The blood pressure of the child in utero is much less than that of the mother; but it becomes greatly increased immediately after the tying of the cord and the establishing of respiration, and continues gradually to increase with age.

This increased blood pressure is probably responsible for the increasing in size of one which remains open to become closed within a few days, at the end of which time the arterio-vascular system has become adjusted to such increased pressure.

CIRCULATION OF THE BLOOD THROUGH THE HEART.

Superior vena cava.—The blood from the head, neck and upper part of the body enters the right auricle from the superior vena cava through an unguarded opening (18-20 mm. in dia.).

Inferior vena cava.—The blood from the rest of the body enters the right auricle from the inferior vena cava, just below the other opening, through an opening somewhat larger than the superior one (27-30 mm. in dia.). The lower margin of this orifice is guarded by a crescentic fold, the "Eustachian valve," which tends to direct the blood entering through the vein upward and medially. This structure is of considerable importance during fetal life, but may be absent altogether in the adult.

Auriculo-ventricular opening.—The blood passes from the right auricle to right ventricle through the auriculo-ventricular opening, which is guarded by the "tricuspid valve." These valves are composed of three fibro-serous segments which are attached, one in front, one to the back, and one (the largest and most movable) to the left edge, between it and the pulmonary opening. These cusps are thick in the center and thin at the margins, smooth on the auricular side, and rough on the ventricular side, the latter being due to *chordae tendinae.*

Pulmonary opening.—The blood passes from the right ventricle to the lungs through the pulmonary artery, which is guarded by the "pulmonary semilunar valves." These valves are semi-circular fibro-serous folds (three in number), which are attached to the pulmonary opening like so many wall-pockets, the free edges coming together to prevent the backward flow of blood. Each flap is thickest at its margin, which has a small fibrous nodule in middle, the *corpus arantii,* from which fibers radiate to the attached base of the flap. When the opening is closed by the flaps the corpora arantii come together and fill up what would otherwise be a triangular opening.

Pulmonary veins.—The blood passes from the lungs through the four pulmonary veins into the left auricle. These openings are unguarded by valves.

Left auriculo-ventricular opening.—From the right auricle the blood passes through the auriculo-ventricular opening into the left ventricle. This opening is guarded by the *bicuspid* or mitral valves, which are composed of two unequal flaps, formed like those of

the tricuspid valve, but being larger, stronger and thicker. The larger anterior cusp is on the aortic side of the opening corresponding with the location of the tricuspid's largest valve in relation to the pulmonary artery. The smaller cusp is behind and to the left. Two small cusps are usually found at the junction of the larger cusps. The attachments of the chordae tendinae are similar to those of the tricuspid, but one chordae are fewer, stronger and thicker.

The aortic semilunar valves.—From the thick walled left ventricle the blood is pumped through the aorta to all parts of the body. The opening through which it passes to enter the aorta is guarded by the *aortic semilunar valves,* which are identical in arrangement with those of the pulmonary semilunar valves, only they are thicker and stronger, and the corpora arantii are larger.

BLOOD SUPPLY OF THE HEART.

The heart is supplied by two arteries, the right and left coronaries. These arteries arise from the corresponding sides of the aorta, just above the margins of the semilunar valves from the prominences which correspond to the sinuses of Valsalva.

The left coronary artery lies behind the base of the pulmonary aorta, and passes forward to the anterior interventricular groove, in which it bifurcates. The larger of these branches supplies the anterior surface of both ventricles, while the small one sends branches to the left auricle and ventricle.

The right coronary artery passes outward from its origin, until it reaches the posterior interventricular groove, through which it descends toward the apex of the heart. In its course it gives off numerous branches to the right auricle and ventricle and to that portion of the left ventricle adjoining the posterior interventricular groove. Usually a large branch, the marginal artery, descends along the right margin of the heart and gives branches to both surfaces of the right ventricle.

These arteries do not anastomose, therefore if either of them is suddenly occluded that side of the heart

can not be supplied by the other artery directly. The lymphatics are direct continuations of these arteries, and form a complete network. So when the occlusion of one of these arteries takes place gradually, a passage from one artery to the other may be formed by their enlargement.

Variations.—The right and left coronary artery may arise from the same stem, or one of them may be wanting, or supernumerary vessels may occur. An accessory coronary artery has been noted arising from the pulmonary aorta; its origin would therefore be above the valves. In the case of Fishbach and R. A. White, the latter my student, while dissecting at the Medical Department, University of Cincinnati, 1914-'15, found this to be the only coronary artery on the right side.

There are two networks of lymphatics, one beneath the visceral layer of the pericardium and one beneath the endocardium. The networks communicate with two sets of vessels, which lie along the anterior and posterior auricular ventricular grooves. The anterior set passes from right to left, around the left surface of the pulmonary aorta to reach the systemic aorta, upon which it ascends to a lymphatic node situated to the left of the trachea. The posterior set empties in part into the anterior one and in part ascends along the right side of the pulmonary aorta to terminate in one of the nodes at the bifurcation of the trachea.

There are two veins bearing the same names, and corresponding very closely to the arteries, under normal conditions and in variations.

The heart is doubtless the best nourished organ in the body, each muscle fiber being accompanied by capillaries.

THE NERVE SUPPLY OF THE HEART

The nerves of the heart are derived from the cardiac plexuses, and passing downward along the aortæ, are distributed to the auricles and partly accompanying the coronary arteries along the auriculo-ventricular groove, where they form the *coronary plexus*, from which the branches are distributed to the ven-

tricles. Over the surface of the auricles and ventricles the fibers form a fine plexus situated beneath the visceral layer of the pericardium, and from this plexus branches pass into the substance of the heart to terminate upon the muscle fibers. There are also some different fibers which are distributed to the pericardium and endocardium, and some to the connecting fibers of the heart walls.

Scattered through the superficial plexuses there are numerous ganglion cells which are especially numerous around the orifices of the great veins opening into the auricles, the coronary plexuses, and over the upper portion of the ventricle. It is also thought that there are ganglion cells embedded in walls of the ventricles.

SURGERY OF THE CARDIO-VASCULAR VALVES.

1. Valvotomy.
2. Valvectomy.
3. Valvorrhaphy.
4. Valvopexy.

Diseases, injuries and anomalies of the tricuspid and mitral valves have at last become surgical entities, and must be considered as such by the surgeon, physiologist and pathologist. Deficiency in valves from any cause may vary in degree, the result being harmless, serious or fatal. The only hope for repair in either event or degree lies in the application of the most modern surgical principles.

Fungosities or calcareous deposits may by erosion partially or completely destroy the function of one or more valves, by perforating them or causing their borders to become irregular, even though these fungosities have disappeared after completing their destruction. These imperfections may also be due to neoplasm, within or without the vessel, directly or indirectly by pressure, or they may be the result of various forms of injuries, applied directly or indirectly. Again, such defects may be due to defective embryological development.

However, before surgical measures can be applied these irregularities must be detected by methods other than are known at this time. But it is reasonable to

hope that symptoms may be classified and diagnoses made so perfect that one may be justified in exploring these valves. The present-day methods of diagnosis must not be discarded, but must be utilized with whatever newer methods may be discovered in the determination of imperfect cardio-vascular valves.

Valvotomy.—Incisions into the cardio-vascular valves may be resorted to for the purpose of removing neoplasms or foreign bodies or to adjust irregularities such as imperfect borders and perforations which may impair their function.

Valvectomy.—The removal of a part or all of one or more valves may be necessary for the restoration of function. When such a procedure is necessary the lumen of the vessel which the valves occupy may be lessened by imbrication or the application of an aluminum or silver band externally and immediately surrounding the valvular attachments. Such a procedure will suffice in preventing regurgitation.

Valvorrhaphy.—The application of sutures to one or more valves may be necessary to close perforations, incisions or lacerations due to any cause.

Valvopexy.—Valvopexy may be necessary when a valve is functionless and the space it occupies may be permanently closed and the associated valves permitted to perform the function for which all were intended. The borders of one leaf may be sutured to the border of its associated leaf.

SURGICAL TECHNIQUE FOR ARTERIO-VASCULAR VALVES.

Valves must be exposed sufficiently by incisions through the most available vascular wall to permit of proper manipulation. Small threads are passed through each incised border for their retraction and the field of operation made clean by small gauze or cotton sponges, great care to be taken to prevent their fibers from remaining in the cavities.

The instruments necessary are a pair of very fine scissors, fine pointed forceps with fine teeth, a Von Graafe iridectomy knife, fine curved round-pointed needles and needle forceps to correspond, and a very fine quality of the smallest silk.

For valvotomy the leaf valve may be held in position by means of the forceps. The tissues may be cut without any great resistance if the knife is sharp. Practically the same procedure is resorted to in excising portions of the leaf valve and whatever sutures may be necessary.

The sutures should be interrupted and about one-sixteenth of an inch apart, but not made taut enough to cut the tissue.

When it is necessary to fix the border of one to the border of another, the sutures should also be interrupted through the entire thickness of the wall of the leaf and about the same distance apart, with the knot made on the upper surface of the leaf.

Should it be necessary to lessen the lumen of the vessel about the valves because of any of these irregularities, a metallic band with well-rounded edges and about one-twentieth of an inch in thickness, and three-eighths of an inch wide, may be made to pass around the vessel at a point to correspond to the attachments of the valves and drawn tight enough to produce the desired constriction. This band should contain small perforations at its ends to permi of it being held in position by a fine silver or annealed steel or copper wire. The completion of this work should be as rapid as possible, and when accomplished the clamps should be immediately removed.

HEART AND VASCULAR SYSTEM.

Carrel, A., and Tuffier, T. Anatomico-Pathological and Experimental Study of the Surgery of the Orifices of the Heart. (Med. Press and Circ., 1914, cxlviii, 539.)

As a result of their researches the authors state that pure mitral stenosis, certain aortic stenoses, and some stenoses of the pulmonary artery will be found, even in well defined cases, to be benefited by surgical intervention.

Aortic stenosis may occupy one of three regions—valvular, supra-aortic, or sub-aortic. The sub-aortic variety is inaccessible to surgical treatment on account of its position below the fibrous ring at the level of the

mitro-aortic canal; supra-aortic stenosis is rare. The truly surgical variety is the valvular stenosis, which is characterized by adhesions between the free borders of the valves with thickening and malformation of the margins. It is simply a ring with indurated margins. Occasionally the lesion extends as far as the fibrous circle of implantation of the valves on the aortic wall. Above the narrowing the aorta is healthy; below, the heart suffers from the effect of the constriction on the current of the blood.

Stenoses of the pulmonary artery present the same anatomical form.

The valvular stenosis is the most frequent form. The fibrous arc of insertion is intact and the welding of the valvular margins creates a sort of diaphragm, convex toward the pulmonary artery, the more or less narrow central orifice of which is susceptible of enlargement. It is a paradoxical fact that the pulmonary artery is dilated above the seat of stenosis, but this is due to the loss of elasticity of its walls. There may be pure stenosis of the pulmonary artery in young subjects, without any alteration of the myocardium or congenital malformation of any other orifice. This condition is one eminently favorable for mechanical treatment.

Congenital tricuspid stenoses, which present the same characters, are especially suitable for surgical intervention on account of the integrity of the cardiac organ.

When an artificial lesion presents itself with the anatomical conditions which permit attack, while the state of the cardiac muscle and coats of the vessel justify the reasonableness of the intervention, it does not follow that such procedure is actually indicated. The lesion which tends to provoke grave or fatal trouble in the near future is the genuine indication that points toward the adoption of surgical efforts. It appears that such indication is of rare occurrence, but it does not present itself definitely in certain cases. Some aortic stenoses of slowly continuous, progressive development, and accompanied with cardiac hypertrophy, may likewise be regarded as mechanical lesions

which are amenable to mechanical treatment; that is, to enlargement of the valvular chink.

In operating the dangers to be avoided are: Wounds of the coronary arteries, hemorrhage, entrance of the air into cavities of the heart and arteries, and, finally, thrombosis. These dangers are not always grave. Wounds of the coronary vein may be tied with impunity, but the vessel should not be ligated at its extremity. Wounds or ligation of a coronary artery have a varying gravity, according to the part of its course affected. Wounds near the origin of the artery, even when made with the finest needle, always cause momentary arrest of the heart's action, which is followed by a relatively prolonged arrhythmia. Central application of a ligature is always fatal; the heart is arrested in diastole and resuscitation is impossible. The The occurrence of hemorrhage within certain limits is not very serious. Its intensity is naturally in proportion to the extent of the wound and also to the direction of the latter. The one hemorrhage which is grave and difficult to arrest is that from the right auricle. There are several means to combat hemorrhage. Hyperpressure should be maintained at a minimum, but in order to obtain a more complete provisional hemostasis suitable to the surgery of the heart it is necessary to arrest the circulation. This is done by applying an elastic ligature to the arterial pedicle for a short period or preventing the blood from entering the heart by compressing one or both venae cavae.

The entrance of the air into the right ventricle does not present any great danger. On the other hand, this accident is an extremely grave one in the case of the left ventricle, as the air penetrates the coronary vessels, producing a fatal cardiac anemia.

Thrombosis is an accident of corresponding gravity, but it rarely occurs. The authors attach great importance to having the margins of a cardiac wound smooth and regular, thus preventing thrombosis. Very fine thread is used in suturing and the endocardium is not included.

The danger zones are then discussed in detail and

the sensitiveness of the various structures composing the heart are dealt with. Certain manageable zones are described, and from their study the authors conclude that the cavities of the heart may be opened singly and their walls resected without grave injury to the ulterior functional capabilities of the organ.

When preparing to operate it is necessary to interrupt the circulation to an almost complete degree. The arterial pedicle and the pulmonary artery and aorta may be compressed for a period not over forty-five seconds, on account of the exaggerated dilatation of the right heart. With regard to separate compression of the aorta, this is better tolerated in proportion to the distance of its seat of application from the origin of the aorta and the possibility of even diminished irrigation of the nerve centers. Simultaneous compression of the pulmonary veins produces death after some minutes through default of oxygenation of the cardiac muscles, but individual forcipressure of these vessels presents no gravity. (Edward L. Cornell.)

The more recent experimental research in surgery of the heart, lung and trachea, by Axel Werelius, (*J. A. M. A.*, Oct. 17, 1914, pp. 338-345), adds much to that already considered.

CARDIOTOMY AND CARDIORRHAPHY.

The heart varies in structure, number of cavities, position, relation to other organs, point of entrance and exit of blood. In some, the venous and arterial bloods are mixed, while in others, principally the more highly developed, the venous and arterial bloods are entirely separated and remain so.

Occasionally the ductus thoracicus becomes anastomosed, embryologically, accident or disease to the aorta, and pours a part or all of its contents into arterial blood to become distributed throughout temporarily or permanently.

The presence of chyle in the blood by the white color of the serum.—Dr. M. L. Heidingsfeld, Cincinnati Society of Medical Research, 1914.

"The presence of chyle, like venous blood in arterial blood, does not necessarily shorten life.

"*Embryology.*—On the thirteenth day, the heart is represented as two straight tubes lying along the sides of the anterior end of the embryo, between the neural folds and yolk sac, and in connection at their wider ends with the vessels that return the blood from the yolk sac. Within a few days the two have united to form one tube already twisted upon itself".

"The heart arising from a double tube in so many animals indicates that the ancestral vertebrate had two tubes instead of one heart such as is now found in the adult, but this can not be proven by any embryological facts".

"*The fifteenth day* finds the heart much enlarged on the under surface of the embryo, between the head and the yolk sac. It is attached in front and behind to the floor of the bony rib, free along the middle portion of its length, which is twisted into an S-shaped loop. The dorsal and posterior end of the loop is the auricular portion of the heart and is separated by a slight constriction, the canalis auricularis, from the succeeding or ventricular portion, which forms the widest part of the loop passing from left to right across the body, and then turns forward sharply to pass into the tunica arteriosa."

"But little is known of the development of the human embryonic heart before the beginning of the third week. At this time there are three visceral arches to be faintly observed in the neck. The heart, represented by a large twisted tube, may be seen between the embryo and yolk sac. These appear simultaneously with the head and neck and the development of the proto-vertebrae".

"*The wall of the heart* is double along its entire length, and consists of an outer meso-blastic tube, in which muscle cells are found on the fifteenth day."

McKenzie and Robertson found that in a bird's heart there is no bundle of His, or other specialized form of muscle tissue connecting the auricles with the ventricles. The sino-auricular node is also absent. There are peculiar nerve structures, or structures in close association with nerves, at the root of the aorta and pulmonary artery. The aorta and pulmonary

artery are surrounded at the basis of the semilunar valves by a loose reticulum of poorly striated muscle fibres in a cellular matrix.

The heart is the subject of injury and surgical operation, both in the cases of election and emergency, and its limitations are not as yet understood. Cardiotomy is done more frequently in cases of election, while cardiorrhaphy is resorted to more frequently in emergencies.

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The traditional conception of the heart as the seat of the vital spark and the home of the soul still flavors our thoughts enough to cause interest in those occasional cases in which even considerale injuries to this organ have failed to lead to sudden or even remote catastrophe. And this feeling persists in spite of the growing experience of the surgeons that operative attacks on the heart are entirely feasible, and the common procedure in laboratory work of drawing a few cubic centimeters of blood from the heart of guinea pigs whenever desired, the last operation being equivalent to tapping a human heart with a calibre trocar and withdrawing one or two pints of blood. As regards the effects of wounds on the heart, the determining feature is less how much injury, than where and how it takes place. Large secondary tumor growths may be found unexpectedly within the heart at necropsy, having produced no effect to indicate their presence, while small gummas in the vicinity of the bundle of His give rise to profound disturbances in function. So, too, with wounds in the heart, oblique penetrating wounds in the thick walls of the ventricles may not leak, because closed by the systolic contraction, and wounds in the auricles usually cause fatal hemorrhage, and wounds in the pathways of conductivity are frequently instantaneously fatal.

"Perhaps the most spectacular of pathologic conditions in the heart are those in which foreign bodies persist in the heart for long periods without causing manifest harm. This condition has been observed most frequently in cattle, which sometimes take nails, needles and similar pointed objects in their food; these articles may migrate from the stomach or esophagus into the pericardium, and sometimes into the heart itself. Galen knew of a deer which lived for a

long time with the point of an arrow in its heart, and Weber, in 1600, describes the finding of an encapsulated bullet in the wall of the heart of a deer. In man such a condition has not been observed so often, but Zesas (*Fortschr. d. Med.*, 1910, xxviii, 649; briefly abstracted in the Journal, July 23, 1910, p. 358.) recently collected and classified reports of 118 cases, which number, of course, represents far less than the actually known cases. The number is rapidly increasing of late, especially through the use of the X-ray, which now sometimes discloses as located harmlessly in the heart a bullet whose whereabouts would otherwise never have been suspected. Increased frequency of necropsies also adds to the number of cases, for occasionally a foreign body is thus found in the heart as a necropsy surprise, as in the case described by Koch, who found a large nail in the entirely healed heart of a man who died from an absolutely unrelated condition. Of the 118 foreign bodies found, described by Zesas, 54 were needles, and 30 were bullets, all the other objects being of diverse nature, with but two or three of such sort having been found. From the predominance of needles as foreign bodies in human hearts, and of nails, needles and pins in bovine hearts, it is evident that such pointed articles do tend to migrate from the point of entrance, however conflicting the experimental evidence on this point may be. Bullets, however, sometimes reach the heart most indirectly by way of the blood-stream, there being several instances in which the missiles have entered large vessels, especially the pulmonary veins, and from there have passed by gravity or by the force of the current into the heart. There are also a few striking cases in which the bullets entering the heart have after a time escaped into the arterial system and caused embolism of most unusual character.

"It would seem that an aseptic foreign body within the heart wall usually causes little disturbance, but if it is within the cavities there may be considerable arrhythmia and cardiac irritability until fibrinous deposits have immobilized and encapsulated it. In one

case a bullet in the heart wall caused no trouble for three weeks, then it penetrated into the ventricle, where it could be seen by radioscopy tossing about violently and causing most violent arrhythmia, until it became stationary after six months. Evidently it is found by radioscopy that a bullet or other foreign body may remain lodged in the heart, unless infection or pericardial hematoma is present. The possibilities of cardiac surgery in such cases are shown by the case of the patient operated on by V. Manteuffel, in which, after the wound of entrance on the anterior surface of the right ventricle had been sutured the bullet was removed from the cavity of the same ventricle through an incision in the posterior wall, recovery being uneventful." (Editorial in *Jour. Am. Med. Assn.*, October 15, 1910..)

Symptoms are always more or less indefinite and unreliable, depending very much upon the degree and location of the trauma. There are no cardinal symptoms, and without external evidences cardiac injuries may never be suspected, even though they may be confined to the heart alone.

Diagnosis.—Cardiac whining, absence of the left radial pulse, and relief from air hunger, dyspnea, and by changing from the recumbent to sitting posture, have been recognized, but they are not constant or reliable. Radiography may reveal the presence of blood in the pericardial or pleural cavity, alone or the two combined, but it can not be relied upon for differentiation of the three conditions.

Differential diagnosis is difficult, if ever at all certain. All authors recognize that definite diagnosis of injury to the heart is very difficult. Hesse states that it can be made positive in only about 50 per cent. of the cases. Where the position of the wound and the symptoms indicate the probability that the heart is injured an operation is justified. While earlier operators sought to avoid opening the pleural cavity, recent writers state that the pleura is generally injured by the original trauma, and that in such cases an intra-pleural operation along the course of the wound gives the best technique. Differential pressure is employed to pre-

vent pneumothorax. There are many different techniques; in fact, the technique must vary to a great extent with the conditions in each case. For discussion of the general principles, see the articles by Pool and by Hesse in *Annalas of Surgery*, vol. 55, and by Brewster and Robinson; also the German articles by Konig, Rehn and Zeidler especially.

Cardiotomy.—While rarely done for surgical purposes, it has occasionally been the means of relieving conditions that could not otherwise have been done. It may be done with a knife or needle directed through an opening in the sternum and through the pericardium, or by dividing the third, fourth and fifth ribs, or their cartilages, that the osteoplastic flap may be replaced. The latter is the method of choice, and should be done under aseptic precautions, and cared for upon those principles. The use of the vacuum chamber is of no avail in surgical operations upon the heart, unless there is an extensive rent in the pleura.

Indications for cardiotomy.—Cysts, abscess, foreign bodies and neoplasms.

Cysts, parasitic, bacterial or otherwise, in the cardiac wall are indeed rare, but frequent enough to demand at least passing mention. They are usually in the thick left ventricular wall, and may contain blood, pus or serum. Only those containing pus demand drainage into the dressings for several days or weeks. The after-care is directed principally to the dressings, which should be sterile. *Drainage* is best accomplished with tape alone, or through a soft rubber tube removed once or twice daily. *Irrigation*, which should be of simple sterile water, is seldom if ever necessary. *Antiseptics* are strictly contra-indicated, and the return flow should equal that introduced into the pericardial cavity.

The walls of cysts containing blood or serum should be sutured after the cavity has been evacuated, but there is some question as to what course to pursue with the incised walls of a pus cavity, probably sutured at once, but drainage through the pericardial space and thoracic wall is absolutely necessary in all until repair is complete.

Abscesses may occur anywhere in the cardiac wall, and they should be incised and drained through an opening made by trephine in the sternum, or by an osteoplastic flap.

Foreign substances have been found in the heart. Wood (1814) reported such a condition, as did also Sherwood and Davis (1834). Since then many cases have been reported. Among those most interesting is the case of Hamilton (1867), where a leaden ball was embedded in the wall of the right ventricle for twenty years, without the cyst becoming infected and without having caused death, which was the result of pneumonia pure and simple. Balch (1867) also reported a case in which the ball remained in the cavity of the heart for twenty years without infection; while Pool (1889) records a case which survived eleven days with a bullet embedded in the apex of the heart.

Foreign bodies have formed within the cavities of the heart or entered from without, and they may remain in the cardiac cavity or wall indefinitely, to be removed by incision, after the pericardium has been incised through an opening made by trephine in the sternum, or by costo-cartilaginous flap.

Reports have been made of a foreign body having been removed from the cardiac cavities, showing that it is a possible procedure, and without infection there should be no great risk.

FOREIGN BODIES.

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Neoplasms may be removed from the visceral cardiac wall, being especially easy when pedunculated;

and, while they have not been removed from the endocardial surface, it is predicted that it will be done when courage dominates and technique made more perfect. Ligature or excision, or suture seem to be the most rational methods for this purpose.

SECONDARY TUMORS OF THE HEART.

By H. LeB. Peters, M.D., and Lindsay S. Milne, M.D., New York. From the Russell Sage Institute of Pathology.

"Although by no means unique, comparatively few cases of tumor of the heart have been reported, especially in American literature.

"Bodenheimer, in 1865, collected forty-five cases, and Hektoen[1] in his report of three cases in 1893 was able to find only 110 cases of tumor of all types exclusive of echinococcus cysts, gummata and tuberculosis masses. Since then others have been reported so that there is reference at the present time to about 150 cases.

"Of the primary tumors of the heart, Berthenson[2] collected twenty-eight, including nine sarcomata, seven myomata, six fibromata, three carcinomata, two lipomata, and one cyst. More recently isolated cases, all sarcomata, have been reported by Raw,[3] Lambert,[4] Hektoen,[1] Bodenheimer,[5] and Wolbach.[6]

"*The secondary growths* to which our three cases belong are more numerous, nevertheless their relative infrequency may be gathered from the following statistics: Blumensohn,[7] in a review of 1,078 cases of carcinomata in general, found secondary heart involvement in thirty-four, while from 160 cases of carcoma twelve showed cardiac metastases. Chambers[8] from 2,161 autopsies found secondary carcinoma of

1 Hektoen: Medical News, 571, 1893, Philadelphia.
2 Berthenson: Virchow's Archiv, cxxxii, 3.
3 Raw: British Journal, 1898.
4 Lambert: New ork Medical Journal, 1898.
5 Bodenheimer: Inaugural Dissertation, Berne, 1865.
6 Wolbach: Journal of Medical Research, vol. xvi, p. 495, 1907.
7 Blumensohn: Inaugural Dissertation, Basel, 1907.
8 Chambers: Revue Medico-Chirurgicale, October, 1853.

the heart in seven cases. Milligh[9] from 4,547 autopsies found nine cases; Kohler[10] from 9,118 autopsies, six cases; Pic and Bret[11] from 1,708 autopsies, twenty-five cases; Thorel[12] from 3,000 autopsies, ten cases; Tadson[14] from 8,289 autopsies, six cases; and in the last 1,976 autopsies in the Russell Sage Institute, New York, only the following three cases have been observed:

Tumor metastases in the heart occur as a result of either direct extension by the lymphatics from neighboring structures, or via the blood stream, either by direct implantation upon the endocardium or by embolism of the coronaries. In this connection Lancereaux and others have found tumor cells in the circulating blood; von Recklinghausen has noted sarcoma tissue in the right ventricle growing upon the endocardium between the papillary muscles, and Tedeschi cites a case of recurrent round-celled sarcoma of the heart in which small bits of tumor were found in the heart clots. The method of spread naturally largely determines the location of the metastasis; thus in tumors other than those of the lungs the right heart tends to be more frequently affected than the left. Cornil[15] from a review of eighty-four cases found, where the tumor was confined to one side, that the right heart was affected thirty-eight times and the left eighteen times. In Case II it was interesting that a metastasis was found in the myocardium of the left ventricle, while no tumor foci were observed in the lungs.

"*In size and appearance* the growths vary considerably from large intramural or polypoid types to a diffuse infiltration of the wall scarcely perceptible to the naked eye. Microscopically they resemble the primary growth.

"*The symptoms* of tumor of the heart are exceed-

9 Milligk: Prager Vierteljaahresschrift, 1856.
10 Kohler: Ibid., 1856.
11 Pic and Bret: Revue de Medicine, No. 20, 1891.
12 Thorel: Ergegnisse der Allgemeinen Anatomie and Pathologie, vol. ix, 1903.
13 Bryant: Johns Hopkins Bulletin, December, 1907.
14 Tadson: Ref. in Saainmount. These de Paris, 1904.
15 Cornil: These de Paris, 1903.

ingly varied, no pathognomonic sign being recognized. Many times, even extensive involvement of the heart is discovered only at autopsy.

"*Palpitation*, precordial pain, cardiac distress, dyspnea, arrhythmia, cyanosis, and other signs of loss of compensation, are sometimes noted. Such symptoms, if severe, occurring in a known tumor case, are suggestive. In several reported cases hemiplegia has developed, and the authors have considered them to be due to embolism from the heart.

The physical signs are also varied and depend entirely upon the situation and extent of the mass; a serosanguineous pericardial effusion may also be found.

"Two of the cases presented practically no symptoms nor signs of the condition, while in the third the polypus connected with the mediastinal growth hung down in the right auricle without producing any distinctive murmur."

CARDIORRHAPHY.

Cardiorrhaphy was done in 1893, by Williams, a negro, and the patient recovered. Since then there have been about 177 such operations, with 71 recoveries. Sometimes the heart is approached through the pleural cavity when it has been already opened, but the most available route is through the pericardium without entering the pleural cavity.

Indications for cardiorrhaphy.—Lacerations, incisions, punctures and ruptures.

Lacerations of the heart differ somewhat from punctures and incisions, in that they are usually more ragged and extensive. They may also be penetrating or non-penetrating in the wall of either one or more of its chambers, and when subjected to surgical operation without complications the treatment is very much simplified.

Incisions.—Stiletto and knife wounds of the heart are penetrating and non-penetrating, are more frequent than all other wounds combined, and are the most favorable when properly treated. Some necessitate the use of general anesthesia, others do not, when

much shock exists. The heart should be approached directly through the pericardial cavity, but if the pleural cavity has been opened it should be done by that route. Unless infected, the wound may be closed immediately, but much alertness is necessary during convalescence, as infection may occur at any time to complicate the after-care.

Punctures may be single or multiple; penetrating or non-penetrating; vary in shape and size, and in any part of the cardiac wall. In either case they may be serious, so that suture should be applied to the slightest abrasion, especially in the muscular wall. The more superficial ones in the thick ventricular wall may not require suture, but this being a question of great magnitude, it is probably safer to apply one or more sutures in all.

Heart wounds recorded up to January 1, 1911.—177 cases reported, 71 recovered, 106 died; 134 operators; knife most frequent; 75 per cent. associated with pleura; only 24 produced by bullets; mortality greater with bullets; technique no special one; drainage; infection with and without drainage about equal in frequency.

Suture of stab wounds of the heart.—Since the suturing of wounds of the heart has become a common procedure, the mortality from such wounds has fallen from 85 per cent. in 1867 to 57 or 53 per cent. in the last few years. Drosdoff has collected 222 cases of cardiac wounds that have been treated by suturing, and 105 of the patients recovered. As the symptoms of stab wounds of the heart are not always clear, the subjective symptoms (general condition of the patient, dizziness, pains in the chest, cerebral manifestations), and the objective signs (hemorrhage, presence of a wound in the chest in the cardiac region, increased cardiac dullness caused by effusion of blood, and abnormal murmurs) being very inconstant, Drosdoff prefers to operate even when there is a mere suspicion of injury of the heart, though a presumptive diagnosis can generally be made from a combination of different symptoms. In a large St. Petersburg hospital the diagnosis was made in eleven out of twenty-one cases.

The operation consists in enlargement of the wound in the chest, resection of the corresponding ribs, and, while the heart is fixed by the finger—which may also help to check the hemorrhage—a silk thread is passed through the epicardium and heart muscle, without waiting for diastole or systole. The suture thread must not be tied too tight. The pericardial wound he advises to leave open and tampon; this helps also in draining. If the wound in the pericardium is too large a couple of stitches are advisable in addition to the tampon. The beneficial results are sometimes striking, no complications in the form of irregular heart action or pericardial adhesions occurring, as Drosdoff's case shows. (*Medizinskoe Obozrienie*, Moscow, lxxix, No. 6, pp. 471-558. Last indexed June 21,p. 198, 1913.)

Operative treatment of wounds of the heart.—Leotta gives statistics which show recovery in 44.91 per cent. of 236 cases in which the heart was sutured. When the left ventricle was the seat of the injury, 46.29 per cent. of the 108 patients recovered; 39.28 per cent. of the eighty-four patients with the wound in the right ventricle; 77.77 per cent. of the nine with the wound in the left auricle, and 62.5 per cent. in the right auricle. One patient with both left auricle and ventricle injured died, and one of the two with both right auricle and ventricle injured. In thirty-five of the total 236 cases, the injury had been done with a firearm. The proportions of recovery with this were about the same as above except that both of the two patients recovered who had both the right ventricle and auricle or the left ventricle and auricle injured.—*Policlinico*, Rome, Sept. xx, Surgical Section, No. 9, pp. 385-432, 1913.

Heart sutures up to August 10, 1915.—Robinson's statistics show 71 successful sutures, 105 unsuccessful; 11 recoveries and 13 failures were bullet wounds. It is generally noted that the larger proportion of operative cases are stab wounds; bullet wounds do not come to operation so frequently.

According to Hesse's statistics of 219 cases of injuries to the heart that were operated, 103 recovered, 47 per cent.; 116 died, 53 per cent. Simon's statistics

show for 241 operated cases, 117 recovered, 49 per cent.; 124 died, 51 per cent.

Zeidler reports 31 sutures of the heart after injury, with 9 recoveries in the Obuchoro Hospital. He believes this to be the longest series of such cases yet reported from any one institution. In some cases he employed cardiolysis, the prophylactic resection of part of the chest wall.

Hacker, writing in 1912, says that the hope has been expressed "that progressive aseptic surgery would permit us to repair defective valves and correct restricting cardiac orifices, but to date this has not become a reality," and Rehn, writing in 1913, says that surgically the heart valves are "noli me tangere." Since Brienton in 1902 suggested the possibility of an operation for mitral stenosis, several experiments have been made with animals, but no operation has been attempted on men. References to the various experiments are given at the close of the bibliography.

Drainage of pericardium is necessary in all cases, but drainage should not be instituted in the pleural cavity when complicating wounds of the heart if it can possibly be avoided.

Ruptures may be in any part of the cardiac wall; vary in size and shape; partial or complete, from within or without, and more or less jagged in character. It is only those that perforate the heart that can be detected on opening the pericardial sac. Clots within the wound sometimes prevent the escape of blood through the smaller ones into the pericardial sac. All should be sutured regardless of their character or location, and are usually complicated.

Erdman reports a case of stab wound of the heart, made by a knife, three-quarters of an inch wide by six inches long, that would correspond to a fruit knife or one used for paring potatoes. The puncture—three-quarters of an inch long—was on the right side of the chest, one and three-quarter inches to the right of the median line, penetrating the fifth costal cartilage obliquely, and splitting its lower three quarters. The distance from the left nipple was six inches to the right of the median line, and on a line one and a

quarter inches below the right nipple. The patient was received at the hospital shortly after the injury, and Erdmann saw the patient about three and a half hours after the injury. In the interval the patient had a transfusion of 500 c.c. of salt solution. His condition at the time Erdmann saw him was one of profound shock, marked pallor, the pulse uncountable, and almost imperceptible, dyspnea, rapid and shallow breathing, cold perspiration, and semi-consciousness. The heart sounds were distant and almost imperceptible. The patient complained of constant abdominal pain, and upon palpation he was found to be exquisitely tender on the right half of the abdomen. On percussion, dullness and flatness extended over this entire region, particularly marked in the upper half. As a result of the pain, dullness and flatness, and the liver might have been punctured or transfixed to such a degree that hemorrhage had taken place into the peritoneal cavity, in addition to an injury in all probability to the outer edge of the pericardial sac. An exploration was begun at the angle between the seventh costal cartilage and the ensiform process. Upon reaching the peritoneum, a deep blue-black appearance, such as seen in rupture of extrauterine gestation sac, was observed. The exploration was then extended two inches further in the abdominal wall, and the peritoneum opened, when the dark blue mass was seen to be the liver, driven downward four inches below the costal margin. It was deeply cyanotic. The peritoneal cavity and the dome of the liver was explored and nothing found to indicate puncture. The seventh costal cartilage was then raised, the diaphragmatic musculature was detached, and the cartilage cut at its juncture with the rib. A retractor was placed on the cartilages, the skin raised from the sternum at the upper limit of the incision with a pair of bone-cutting forceps. The cartilage and bony flap were raised to the left by forcibly dragging upon the retractor previously placed upon the cartilages. Upon raising the flap a hole admitting the index finger was found penetrating the pericardium. This was enlarged by a transverse incision one-half inch long toward the me ion

of the mediastinum. The index finger was inserted and explored the contour of the heart, when a hole was found in the right ventricle admitting the gloved index finger. The pericardium was then incised upward and downward in the median portion of the mediastinum, so that an exposure was made for four inches in length. Upon making this opening in the pericardium an immense amount of clot was expelled, with some liquid blood. At this point the heart slipped from his fingers. The finger was again rapidly introduced and the palm of the hand above, and the thumb below, grasped the heart, while the index finger was retained within the ventricle. A curved needle, threaded with No. 2 plain catgut, was then placed down to the heart, and during a systole puncture was made irrespective of penetrating the cavity or not. As soon as the needle had pierced one side of the incision, the finger was withdrawn and the needle made to make its exit from the opposite side. A knot was tied and the heart held dangling from this suture. The subsequent stitches—eight or ten in number—were readily placed, one more being placed in the line of the heart wound proper, and two more rows placed after the manner of Lambert. A long cigarette drain was placed in the pericardial cavity, the incision in the pericardium closed up to the emergence of the drain, which was led out at the angle of the seventh costal cartilage and the sternum. Catgut stitches were taken in the costal cartilages between them and the ribs.

"At the Surgical Congress, Berlin, June, 1911, Hr. Hesse of Dresden showed cases of recovery after wounds of the heart. He said that of six cases in which he had operated, five had recovered (these were the cases shown). An important diagnostic sign of injury to the heart was hemothorax. He was unconditionally opposed to any waiting measure. He was also opposed to the use of stimulants before operation; he gave morphia only. As regards the incision, he was an advocate for individualization, the points to be kept in view being accessibility, the possible need for enlargement of the wound, and drainage. The ideal was an entrance outside the pleura and treatment with-

out drainage. In injuries of the auricle plenty of room was required. Here luxation of the heart was of no assistance, one had to work in the cavity of the chest, where at an operation the pleura had to be kept open a long time. The cavity should be drained. The danger of pneumothorax was less than that of pleuritic infection."—*Med Press and Circ.*, June 21, 1911.

Hr. Hesse reported twenty-one operations for wounds of the heart, nineteen of which were punctured and two gunshot. Of these six recovered. Of the fifteen that died, the death was death to acute anemia in eleven, in four to infection. In regard to prognosis it was of importance whether operation was performed within the first four hours or not. If within the four hours, 75 per cent. of the cases recovered. Any abnormal sound at the heart was heard only once. In eight cases symptoms of tamponade of the heart were present. In 38 per cent. the external wound was outside the cardiac region. All the cases of wound of the auricle died. All the patients that recovered were able to follow their employment. Hr. Fuchsing was in favor of operating through the diaphragm for deep-lying wounds.

Dr. Fraancis T. Stewart, of Philadelphia (*Journal Amer. Med. Assn.*, June 21 1913), reports five cases of suture of the heart in the following manner:

Case 1: Symptoms of acute anemia and hemopneumothorax. Staab wound of left ventricle, three-fourths inch long, continuous silk suture. Ligation of descending branch of left coronary artery near its origin. Drainage of pericardial and pleural cavities. Pyopericardium and pyothorax. Recovery. Death five years later from pulmonary tuberculosis. At necropsy the wall of the left ventricle was the seat of interstitial myocarditis, and in one place near the apex greatly thinned.

Case 2.—Symptoms of acute anemia and hemopneumothorax. Stab wound of left ventricle, one-half inch long. Continuous silk suture. Suture of pericardium, drainage of pleural cavity. Pyothorax. Recovery. Patient still well four years and three months after injury.

Case 3.—Symptoms of compression of heart. Pleura not injured. Stab wound of right auricle, one-fourth inch long. Continuous catgut suture. Closure of pericardium. Pleura not opened during operation. Recovery without pyopericardium or pyothorax. Patient well after two years.

Case 4.—Symptoms of acute anemia and hemopneumothorax. Stab wound of left ventricle, one inch long. Continuous catgut suture, closure of pericardium, drainage of pleural cavity. Death in forty-one hours. Necropsy, pyothorax, purulent pericarditis, acute infective myocarditis, acute vegetative endocarditis.

Case 5.—Symptoms of acute anemia and hemopneumothorax. Stab wound of right ventricle, one and one-fifth inches long. Continuous catgut suture. Closure of pericardium, drainage of pleural cavity; death in one hour. Autopsy, wound passed into right ventricle, then through the septum into the left ventricle. Both ventricles were hypertrophied and the mitral valves were badly diseased.

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Reprinted from THE LANCET-CLINIC, August 27, 1910.

SURGERY OF ANEURISM OF THE AORTIC ARCH AND ITS BRANCHES.*

BY BENJAMIN MERRILL RICKETTS, M.D., LL.D.,
CINCINNATI.
Honorary Professor of Surgery American Medical College, St. Louis, Mo.

ARE the internal aneurisms to be known forever as medical, to defy surgical attempt, and treated by useless medication and electrical gymnastics, or are they to be classed as surgical, to be attacked by modern surgical ingenuity? The reply to these questions will have much to do with progress in vascular surgery.

A positive reply to the first would indicate that nothing more may be expected to cure a condition that has so long baffled surgical skill.

A positive reply to the second would indicate progress, the watchword of the scientist. Which of the two shall prevail?

Distal ligation, gradual arterial closure and filipuncture have been the only surgical methods resorted to, but they have not proved definite or desirable, though in a few cases cure and in many more benefit has resulted. With all the good that surgery has accomplished with aneurism of the arch and its branches, but few have been operated upon by any method. Why is this so?

Ligation of blood-vessels was the first step upon a surgical ladder that has been gradually mounted until there are seemingly but few rounds remaining unoccupied.

Filipuncture, with and without galvanism, has for twenty years been employed with more or less benefit, and with an occasional resulting cure. It is

* Read before the Chicago Medical Society, February 16, 1910.

the most irrational of the two methods, because of the great danger of the wire passing into the main blood channel, there being no possible way of determining the character or location of the opening from the vessel into the sac, such an accident cannot be prevented.

Recent advance in the surgery of the vascular system has been beyond reasonable hope of the earlier masters who added so much to the sum total of our knowledge of cardio-vascular surgical possibilities. It is evidenced by the many and perfect results which have been accomplished in both injury and disease.

Ligation, clamp, excision, suture and anastomosis have each been necessary factors in perfecting endo-aneurismorrhaphy, so successfully accomplished by Matas and his followers. With the exception of aneurisms of any portion of the aorta from its origin to its bifurcation, there are but few veins and arteries that have not been successfully attacked by one or more of the many ingenious methods devised for the purpose.

That aneurism of the aorta resisted direct open surgical attack absolutely is proof of the seriousness of such a procedure, but is this sufficient evidence to deter skilled hands from attempting to apply ways and means suggested by present-day surgery, which has accomplished so much? Not at all, for there are more fields to conquer by masterful hands, and there is no reasonable doubt that the surgical goal is just as far beyond our grasp as it was beyond that of the giants of long ago. As yet there has not been any surgical boundary assigned, and it is to be hoped that there will be none to interfere with supply and demand of material for experimental physiology and surgery, as it pertains to animals and possibly criminals.

The aortic arch and its branches, not having been attacked by direct surgical suture, will be especially considered. In no instance, so far as can be found recorded, has suture of any portion of the aorta been applied for the cure of aneurism, or anasto-

mosis, with resulting preservation of the life of the subject.

Perforation or wounds of any character resulting from injury, have not been attacked soon enough to prevent fatality, and aneurisms have defied direct suture beyond reasonable tolerance.

It is thus found necessary to limit the consideration of this subject to (1) distal ligation; (2) filipuncture; (3) endo-aneurismorrhaphy; (4) direct gradual arterial closure.

While the method of Valsalva will only be mentioned, the other methods, such as pressure, massage, acupuncture, injection and galvanopuncture, will be considered from a statistical point of view, according to Wyeth, who gives a most exhaustive review of the surgical anatomy and work upon these vessels (Wyeth's Essay awarded the prize by the American Medical Association in 1878). This has been made so complete that it is found necessary to refer to it frequently. A debt of gratitude is due to him from mankind in general, and there is no place more honorable than this to express it. It is this character of work, done at great sacrifice, that offers the necessary evidence to induce further advance in experimental surgery.

The anatomy of the thoracic vessels is not an exception to the rule, as it, too, may be normal, anomalous or pathologic, or the position may be malformed by accident or disease.

Normal anatomy is that relation of tissues which is supposed to be most frequent and perfect, and which is taught in a routine way.

A normal aortic arch should be of regular curve, and the lumen about the same dimensions in caliber. From it should originate the innominate, left common carotid and left subclavian arteries, and, associated with each of these, in close proximity should be veins which should equally correspond in size, shape and character.

Keith (*Journal of Anatomy and Physiology*, London, xxix, 453-458, 1894) comments on the modes of origin of the carotid and subclavian arteries from

the arch of the aorta in some of the higher primates. This is a most valuable contribution to the subject, and should be given careful consideration.

Anomalous Anatomy is that with any variation from the normal, due to defective embryonic development. Adult hearts have been found with two, three, four, five and six cavities respectively. Crisp,

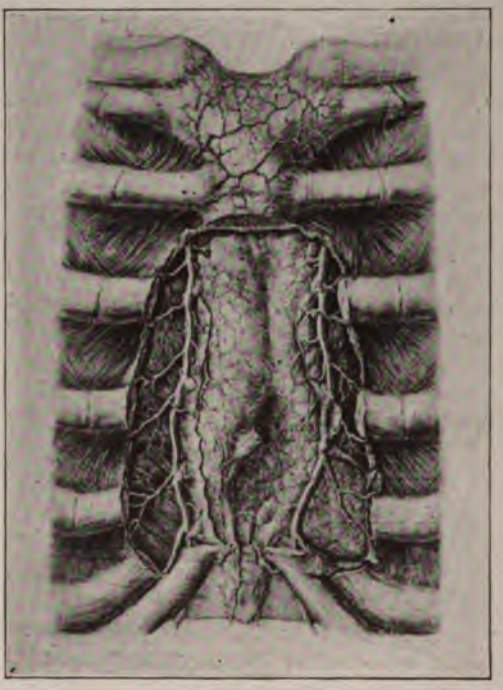

FIG. 1.—Exposed internal mammary arteries (Deaver).

1846, reported one with only a single auricle and ventricle. Indeed, there may be complete transposition of the heart and aortic arch to the right of the median line, with corresponding transposition of the aorta and its branches.

The aortic arch may vary in degree of curve, size, position, thickness of its walls and general contour. The cardio-aortic valves have been found to vary in number, shape and position. The aorta has been

found by Bury to arise from the right ventricle, and the superior vena cava has been found absent, so has also the pulmonary artery, the aorta arising from the right ventricle.

Herringham (Trans. Clin. Soc. Lond., xxv, 46-48, 1891-2) reports a case in which a right aortic arch passed behind the esophagus to the left side, and,

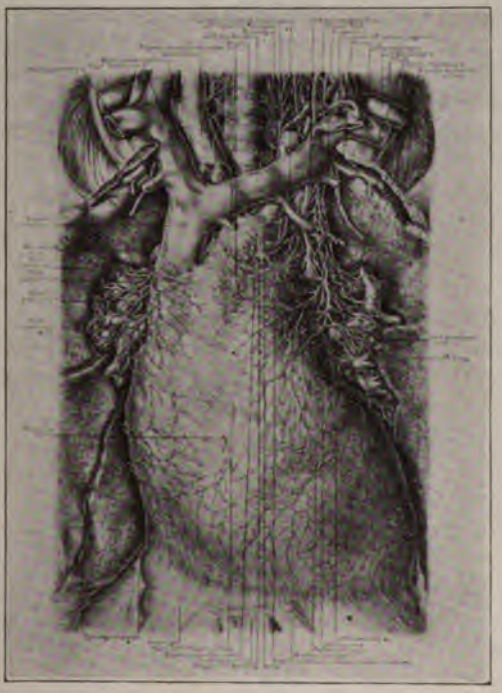

FIG. 2.—Exposed pericardium and blood-vessels (Deaver).

becoming dilated, killed the patient by slow compression of the trachea.

Stuertz, 1894, mentions a case of obliteration of the aorta, and Holt reports a case in which the aorta arose from both ventricles, but principally from the right.

The innominate artery may vary greatly in its point of origin from the aorta, in size, shape, length and direction.

The right subclavian artery may be represented by two arteries arising from the innominate, or it may originate directly from any of the three divisions of the aortic arch, as may the left subclavian also.

Either or both common carotid arteries may originate by one stem in the arch, innominate or either subclavian artery, and bifurcate close to the point of origin, or one common carotid may be entirely absent. Any one or all of these vessels may also vary in size, length, shape and direction. In any event all anatomical relations are more or less changed and complicated.

The veins are also subject to these same variations, and not seldom constitute serious complications in arterial surgery.

The pathology as herein applied pertains mainly to the variations of aneurism, and not to their causes, because it is the character and location of the sac and the opening into it that most pertains to its surgical aspects.

It is therefore found necessary carefully to consider the three anatomical features, so that the surgical possibilities may be better understood.

The change in size, shape and direction of an aneurism may vary from slow to rapid, depending on the condition of the arterial wall, the integrity of the aortic cusps, and the energy of the cardiac muscle. The size of the opening into the sac may also be a factor in their course.

The sacculated is the most desirable form of aneurism for direct operation by ligation, introduction of wire or suture. It is also most favorable for treatment of any character.

Suture would seem most applicable in the sacculated variety when the opening is in the anterior or lateral wall, though it may not be an impossibility with a posterior opening.

The fusiform is the most difficult of the two varieties of aneurism least amenable to surgery. Especially is this so with aneurism of the aortic arch,

because of the small amount of the vessel available by exposure.

The sac and opening into it are usually small, and the general contour of the sac may vary greatly, from round to ovoid, and the size from one inch to ten or more inches in diameter.

In no case has the location of the sac or opening into it been determined before operation, and in but few has it been made clear by autopsy.

Ascending.—The juncture of the first and second portions is the weakest point in the arch, and is supposed to be due to the entrance of the innominate and the pressure of the blood upon the roof of the arch. It is second in frequency for aneurism.

The transverse, or second portion, is first in frequency for aneurism.

The descending, or third portion, is seldom the seat of origin of aneurism, unless such be due to infarct or injury, or associated with aneurism of the first and second portion, or the innominate, subclavian or common carotid.

Arch.—It is found necessary to deal independently with the ascending, transverse and descending portions of the aorta with reference to suture. Lesions originating in the innominate, common carotid or subclavian also demand their individual care, but when all are involved, surgical ingenuity is taxed to its fullest capacity, because this is when readjustment of the blood current may become necessary to offer any hope whatever with suture.

Ascending Aorta.—When the sac and the opening into it are upon the anterior or lateral walls of the ascending aorta, the work should be done through an opening in the anterior wall of the chest.

Transverse Aorta.—When the sac and the opening into it are upon the top and left lateral wall of the transverse aorta, the work should be done through a similar opening.

Descending Aorta.—When the sac and the openinto it are upon either lateral or posterior wall, a posterior opening into the thoracic wall will be necessary.

The greatest difficulty arises when the sac with the opening into it is upon the posterior wall of the ascending portion, the lower wall of the transverse portion and the anteroir wall of the descending portion of the thoracic aorta, unless the opening into the sac be sutured through an open vessel.

The work may be limited to imbrication or the introduction of wire with either an anterior or posterior thoracic opening.

Rupture of aneurism of the arch of the aorta into the pulmonary artery has been reported less than fifty times, one such specimen from a syphilitic subject was recently presented by Dr. J. E. Greiwe to the Cincinnati Academy of Medicine. Death probably was not due to the rupture alone, for there was evidence that the opening was of long duration.

Symptoms, Diagnosis and Differential Diagnosis. (Lang, Babcock and Gibson freely quoted.)—With normal anatomical relations of the thoracic viscera, diagnoses of aneurisms are most difficult; when these relations are anomalous there is still greater difficulty; but when the relations are both anomalous and pathologic the difficulties are many more times multiplied.

It would be difficult to consider properly the diagnosis of aneurisms of any one or all the three divisions of the arch without referring more or less to aneurisms of the vessels arising from it, because of the frequent involvement of two or more, and sometimes all, in a given case. For this reason it will be necessary to consider all, though it is the arch aneurisms that will be especially considered.

Symptoms may be subjective and objective, or there may be no symptoms at all, for the largest aneurism may exist without causing any symptoms, physical or otherwise, to indicate its presence. Death, sudden or prolonged, due to rupture, may ensue without any intimation whatever of its presence.

Dyspnea or cough is the earliest and most constant symptom of aneurism.

Percussion, except in superficial sacs, is more certain than with large and deep-seated sacs, but it is uncertain with all.

Systolic bruit over the sac is one of the most positive indications of aneurism. Heart and radial pulse indications negative.

Tracheal tugging is inconstant, but found in about 10 per cent. of the cases.

Palpation upon an eroded or bulging chest is almost positive, but pulsation in the episternal space is not always so. It may usually disappear as the result of increased coagulum.

Pain, dyspnea, dysphagia, paralysis and spasm may result from pressure. The pupils may be unequal as the result of pressure upon the sympathetic.

Displacement downward of the heart may be forward or to the left. Pain is due to pressure on intercostal nerves, or branches of the brachial plexus, and will follow the course of the nerves, with tenderness especially to the left of the sternum. There is not so much pain if the tumor grows inward, but with dyspnea and cough the pain is rather constant and radiates, with dull heavy sensation which changes with body position with the larger sacs. The chest wall becomes more prominent and the hard structures overlying the sac are absorbed.

Dysphagia may be indicated by food being immediately regurgitated upon entering the stomach. It may be due to direct pressure upon the stomach or reflex disturbances of the splanchnic nerves, and diarrhea or constipation may result.

Diagnosis is uncertain, many times even with the aid of the X-ray. X-ray expansile pulsation is not always a pathognomonic sign of aneurism, though it is more certain in the small than the large sacs. Such expansile pulsation may indicate mediastinal neoplasm. As the X-ray will detect many aneurisms in their earlier development, much good may be expected from its use, because it is the

smaller sacculated form that offers the greatest opportunity for surgical remedy.

Dyspnea, cough, deep-seated pain in the chest and many other chest symptoms, justify the use of the X-ray.

Differential diagnosis is exceedingly difficult with regard to the following conditions: (1) aneurism

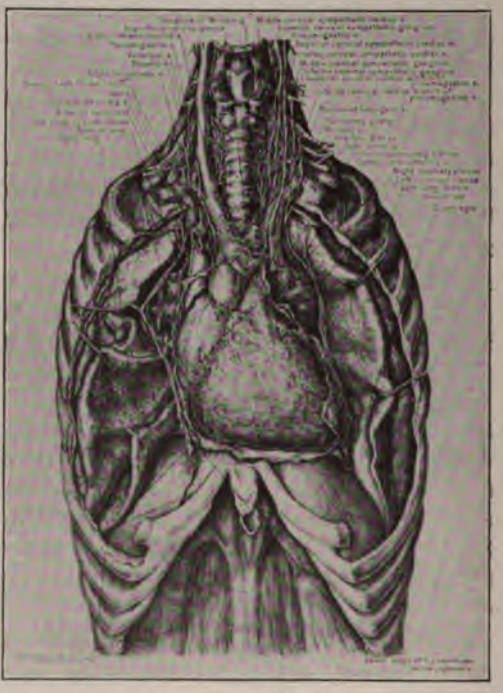

FIG. 3.—Exposed heart and blood-vessels (Deaver).

of the arch; (2) innominate; (3) arch and innominate; (4) carotid artery common; (5) subclavian artery; (6) innominate and carotid; (7) innominate and subclavian; (8) carotid, innominate and subclavian; (9) arch, carotid, subclavian and innominate.

The X-ray may show any of the following conditions: Sinuses of Valsalva and all forms of mediastinal neoplasm and cysts, such as widening

due to aortic dilatation, aneurism, tuberculosis, carcinoma, sarcoma, Hodgkin's disease, fibroma, lipoma, enlarged thymus, dermoid and other cysts.

Any one may be overlooked by anterior or posterior exposure, but may be detected by a lateral exposure.

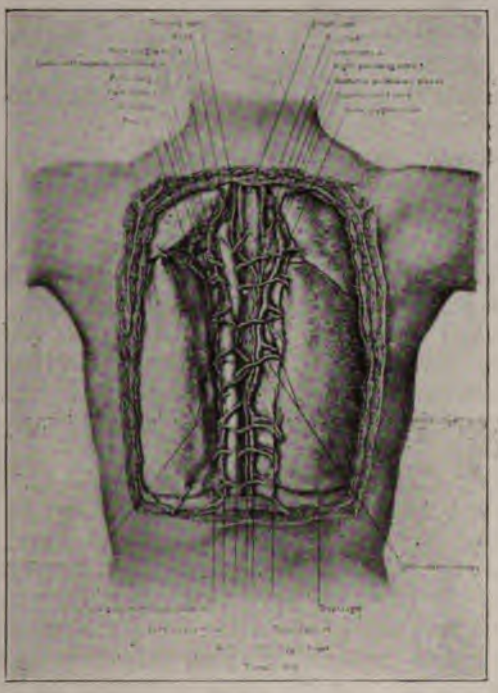

FIG. 4.—Posterior view of lungs and blood-vessels (Deaver).

Pulsation of pulmonary vessels may simulate late aneurism.

Causes of aneurism, such as syphilis, tuberculosis, neoplasms (malignant or non-malignant), rupture, injury and over-taxation of blood capacity must be considered both in diagnosis and treatment, for those aneurisms due to syphilis are supposed to occasionally yield to syphilitic remedies, and they should be given to the degree of tolerance for sev-

eral weeks before an aneurism in a syphilitic should be subjected to an operation of any character.

Aneurisms of the arch, like those of other vessels, have been known to result in spontaneous healing. It is therefore advisable to subject patients with aneurism of any variety to such treatment as rest, change of habits, diet, occupation and environment for a similar period, even without a syphilitic history, but KI and mercury should be given for a reasonable time to all suffering from aneurism due to any cause.

Arterio-venous anastomosis, due to injury, disease, or congenital defect, may be determined by the presence of CO_2 in the blood. Dr. J. E. Griewe recently informed me of this discovery at the Charite Hospital, Berlin, in a patient with supposed congenital perforation of the septum. This is an important discovery, but there is no record of any attempt having been made to discover this gas in the blood of patients known to possess an aneurism, and especially known to have an arterio-venous anastomosis of any character due to any cause. Possibly CO_2 cannot be found in arterial blood before it passes an arterio-venous opening, because it would be carried beyond with the blood current. If this should prove to be so, the location of such an anastomosis could be determined in the extremities without other indications. Blood below would contain CO_2 while that above such an opening could not. The opening would necessarily be located between the two points of puncture. With such an opening in the aorta before the origin of the innominate, the entire vascular system, except the coronary arteries would contain CO_2. But if the opening is distal to the subclavian the rule of the absence of CO_2 should obtain with blood in the branches of the aortic arch.

Not all animals have a pure arterial blood, that of many being arterial and venous blood mixed throughout its circulation, and there is no apparent reason why those, such as mammals, which have a pure arterial blood, should not live and become

thoroughly adjusted to a mixed arterial and venous blood. These questions, however, if not already settled may soon be settled by experimental surgery, and the finding may prove to be of great benefit in vascular surgery.

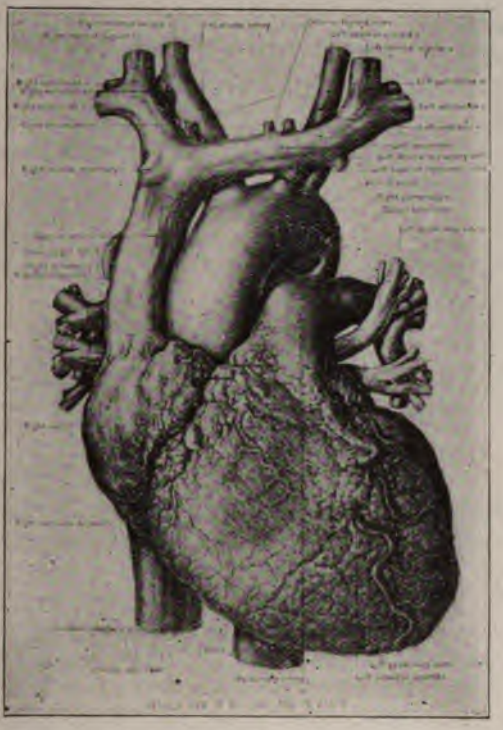

FIG. 5.—Exposed heart and blood-vessels, anterior view (Deaver).

SURGERY.

a. Distal ligation.
b. Filipuncture.
c. Endo-aneurismorrhaphy.

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Distal ligation has been applied to the subclavian, innominate, common carotid, and common carotid and subclavian arteries for aneurism of the arch and its branches.

The common carotid artery was ligated for aneurism and other purposes 789 times before 1878, with a mortality of 4½ per cent. Other arteries have been ligated as follows in frequency:

Internal carotid	18 times
External carotid	91 times
Innominate	16 times
Subclavian, first division	19 times
Subclavian, second division	13 times
Subclavian, third division	237 times
Innominate and subclavian	16 times

From 1878 to 1896 there have been 21 cases of arch aneurism treated by ligation of the common carotid and subclavian arteries.

Distal ligation has been done rather promiscuously, because of inability to determine the origin and character of the lesion. It is, however, known that a few aneurisms of the arch and its branches have been cured, while more have been benefited, and still more not benefited at all.

This very great discrepancy is no doubt due to the promiscuous application of ligature, for if the condition could have been more properly determined the results would have been better, as they should now be by the more modern and positive means for diagnosis.

Ligation for aneurism of thoracic vessels was suggested by the results of distal ligation for aneurism in the vessels of the extremities. Dogs have survived the ligation of both common caro-

tids, and vertebrals and man has been known to survive the simultaneous ligation of both common carotids, and with interval ligation.

Ligation of one subclavian or one common carotid and one subclavian and one common carotid has been done frequently with now but a small mortality, and without the loss of the arm. It is therefore reasonable to suppose that both subclavian arteries may be ligated simultaneously without increased mortality or jeopardizing the life or the arms. Perhaps both subclavian arteries and one common carotid artery may be ligated without fatality, possibly both subclavian and both common carotids.

These suggestions are important, because the question of the surgical treatment of aneurisms of these vessels, with or without involvement of the arch, may be more definitely settled. Possibly its solution may lie in the sacrifice of one and the anastomosis of the other common carotid or subclavian arteries or both, or anastomosis to whatever live artery or vein be convenient.

It has been proved that certain arteries may be successfully anastomosed with their associated or other veins or arteries and the circulatory function of each permanently preserved. This fact may be an aid in applying the necessary surgical technique to the cure of aneurism of the aorta and other arteries.

Distal ligation is applicable for all forms of aneurisms, and is the operation of choice for those which cannot be sutured, or into which wire should not be introduced.

Ligation of the innominate, or subclavian, or one common carotid artery at its origin may not only cure an aneurism involving them, but it may also be curative with certain forms (probably sacculated) of aneurism in any portion of the arch, especially when it is proximal to the origin of the vessel ligated.

Innominate.—The location of the sac and opening into the innominate vessel vary greatly; those

behind the vein and in the posterior wall being inaccessible. Indeed there is a great question of the propriety of ever resorting to such a critical operation as suture of an aneurism in an artery that can be cured by ligation with a mortality probably less. Time will, however, determine this question, so it is with the carotid and subclavian arteries, when they are alone involved, because, as has been stated, their ligation will many times result in a cure.

Hemorrhage following distal ligation for aneurism of the aortic arch, innominate, or subclavian artery, or any of their combinations, is due to the size or manner, or both, with which the ligature has been applied, infection or the pathologic condition of the walls of the vessels involved.

Methods of applying the ligature vary greatly and are no doubt responsible for the greater number of hemorrhages. It is evident that the diameter of the ligature has been too small, regardless of the kind of material of which it was composed. Ligatures of whatever material should correspond in size with the vessel they are to surround.

That more than one ligature should be applied to the aortic branches, their immediate branches, and vessels supplying important organs for any purpose, there can be no question, even though the use of but one has prevailed.

But when ligation is to be done for aneurism, not only two, but three, four, or five, may be necessary to serve the purpose best.

The accompanying illustrations will serve for after demonstrations of the use of the ligature.

1. Shows the first step in the application of ligature so long in vogue.

2. Defines the double ligature, which is seldom employed, but which should so far as possible always be applied to the vessels of the leg and forearm.

3. Shows three ligatures, the middle one completely closing the lumen, while the other two but partially do so. They should be applied to the

subclavian, common carotid, axillary, and common iliac arteries.

4. Illustrates a location which a ligature should never occupy, especially in large vessels.

5. Represents the position that a single ligature should occupy for occlusion of any vessel near its origin.

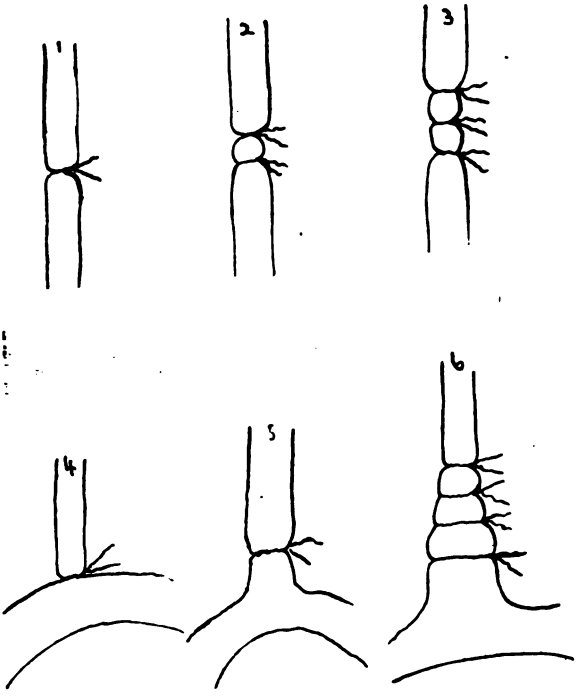

FIG. 6.—Methods of applying ligatures (Ricketts).

6. Might be termed a compound ligature, and is most applicable when it is necessary to occlude the larger vessels, such as the innominate, subclavian and common iliac.

The principle involved in the use of Nos. 3 and 6 is to lessen the amount of the volume of the blood before it reaches the point of occlusion. Ligature No. 2 is not drawn so tightly as ligature No. 1, and therefore only partially occludes the vessel, while

it is completely occluded by ligature No. 1. The ends of the vessel are thereby made funnel shape.

The same result is obtained in No. 6, but more ligatures are necessary, because of the greater size of the vessel. Each ligature may be adjusted with a needle passed through the soft structures immediately overlying and in close contact with the vessel.

The funnel shape induces a more rapid formation of the blood clot and distributes the blood pressure more equally upon the ligatures.

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Aneurism of the aortic arch is usually of such a character as to destroy the anatomical arrangement of the first, second and third divisions, except possibly in the early development of the sacculated variety, with but a small opening in the sac.

Aneurism of the aortic arch was first treated by ligature of the right common carotid artery by Hobart (1839), but it was supposed to be done for innominate aneurism. The patient died on the sixteenth day. Velpeau (1868) deliberately ligated the common carotid for an arch aneurism, lived five months, and the sac was solid with fibrin. Heath (1872) reported one case in which the patient lived four years then ruptured suddenly; Cockle (1872) one, lived one year; Holmes (1875) one, alive at thirteen months; Annandale (1875) one, alive at seven months; Bryant (1876) one, died on the tenth day; and Spier, one, who died on the thirty-fourth day. Wyeth says that ligation of the common carotid artery, for arch aneurism, is not to be advised.

Personal reports are limited alone to distal ligation, with all, the immediate results were remarkably beneficial, and equally so with one for five years. They were, to say the least, encouraging, whether the lesion was in the arch alone or in one or more of its branches, or both, or whether there was an absence of aneurism in either.

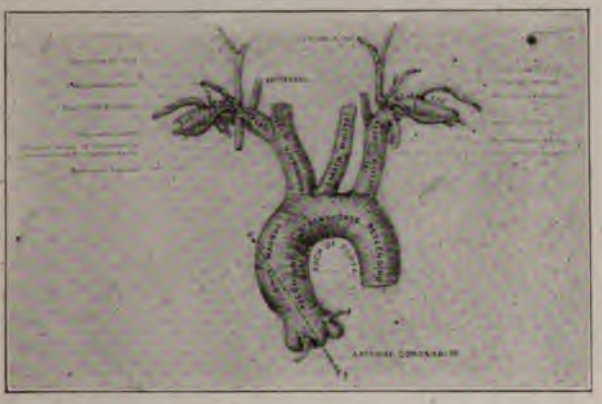

FIG. 7.—The arch of the aorta, the great vessels springing from it and their relations to each other. The three surgical divisions of the subclavian arteries and their branches. The average arrangement deduced from carefully measured dissections of 26 subjects—one-half of each sex. (Figure reduced from life-size drawing.) (Wyeth.)

It is to be regretted that autopsies were not made in each case, that the diagnosis might have been proved or disproved, and that the true pre- and post-operative pathology could have been determined.

CASE I.—Mr. Babb, patient of Dr. H. A. Beeson, Leesburg, O., white, age twenty-five, weight 150, occupation, blacksmith and wagonmaker. No specific history; complained for several months with the usual symptoms of aneurism of the arch. Diagnosis verified by several competent physicians.

He had become somewhat emaciated and completely incapacitated for his work. During 1895 two kangaroo tendons were applied to both the right common carotid and subclavian arteries, con-

suming but ten minutes' time under chloroform narcosis. He recovered from the operation without shock, remaining in bed but about fifteen days, when he returned to his home by rail, sixty miles distant. His condition improved rapidly, so that he resumed part of his work at the end of four months. He gradually resumed the duties of both his occupations. He continued in a most excellent condition for about five years, at the expiration of which time he was found dead, sitting on the seat in an outhouse near by, as the result of probable rupture. The family would not consent to an autopsy.

CASE II.—Mr. Artman, white, about fifty years of age, Somerset, Ky., patient of Dr. I. S. Warren, occupation that of a conductor on the Mexical Railroad, entering the city of Mexico. He gave a history of aortic arch aneurism of several months' duration, without syphilitic complication. He could not lie down, slept in a chair, lost weight and appetite, while symptoms increased in severity. During September, 1901, two kangaroo tendons were applied to both the right common carotid and subclavian arteries within twelve minutes' time, under chloroform narcosis. He could thereafter lie prone upon the bed, cough and pain ceased, and he left for home, 180 miles distant, on the tenth day.

Improvement was rapid, and he returned to work after a few weeks, but died on December 8, 1901, with pneumonia, contracted while exposed without his coat.

CASE III.—Mrs. Metcalfe, Brocksville, Ky., white, housewife, aged fifty-six, well nourished, suffered for about eighteen months. On December 13, 1903, under chloroform narcosis by her physician, Dr. Corliss, two broad kangaroo tendons were applied to each the right common carotid and subclavian arteries, occupying but twelve minutes' time.

She improved rapidly, soon being able to leave her bed and chair, which she had occupied for several months. She remained comfortable for about five months after operation, when she rapidly declined to a fatal termination during May, 1904.

The radial pulse continued manifest, but faint. The subclavian probably had two origins. Consent for an autopsy could not be obtained.

CASE IV.—Morton Barnes, patient of Dr. R. E.

Holmes, Leesburg, O., male, white, thirty-eight years old, six feet high and 170 pounds in weight, occupation that of a civil engineer in the Rocky Mountains. Specific history of twelve years. Began to complain with shortness of breath about February, 1908, and dyspnea followed with the usual symptoms of aortic aneurism. The tugging of the trachea and incessant hacking cough were severe; appetite was poor, with loss of flesh. Pain in upper chest and left shoulder severe. There was considerable prominence of the supraclavicular spaces.

I first saw him on September 9, 1908, when one No. 2 chromicized catgut was applied to each the right common carotid and subclavian arteries, consuming but twelve minutes' time under chloroform narcosis.

There was practically no shock, and he improved rapidly until September 21, or for eleven days, when the sac suddenly ruptured, resulting in death within fifteen minutes. During the eleven days intervening the cough ceased, appetite returned, shortness of breath disappeared, and he expressed himself as feeling more comfortable than he had for several weeks. He persisted in sitting erect in bed after the fourth or fifth day, though advised not to do so. Rupture occurred in an attempt to sit erect. Consent could not be secured for an autopsy. Would the result have been different had two ligatures been applied? Was not hemorrhage due to but one ligature?

Two of the four personal cases developed while the subjects were pursuing their vocations at altitudes varying from 4,000 to 8,000 feet. Whether these four cases had an aneurism of the arch or its branches, one or all, will never be known, but all the symptoms to indicate aneurism of the arch were present. X-ray was not applied to either.

The innominate artery was first ligated by Mott (1818), the patient living twenty-five days. Wickham (1829) also did it. Twenty-three such operations were made before 1878.

Jacobsthal (*Centralblatt f. Chirurgie,* August 23, 1902) reports a case of aneurism of the innominate artery, treated by ligation of the common carotid artery, with death of the patient at the end of fifty-

one days, no improvement having been noticed. He concludes that the operation probably increases, rather than lowers, the intravascular pressure.

Of 94 cases collected by Poivet, 7.4 per cent. were cured; of 23 cases collected by this writer, 13 were partially relieved by distal ligation, but in no case was the patient under observation for a longer period than one year, and in no case was a definite cure recorded.

The innominate mortality is said to be 55.7 per cent. Of 33 cases treated by methods other than distal ligation, 15 were improved, and one patient in whom filipuncture and electrolysis were used, died at the end of three and a half years, the autopsy proving that the aneurism had been cured. (*Philadelphia Medical Journal,* February 14, 1903, p. 309.) The following cases have also been reported: Wickham (1829), one recovered, lived five months; Rigeon (1829), one recovered, lived four months, died of other cause, sac filled with fibrin; Key (1830), one, died in four hours; Fearn (1836), one, recovered, lived two years; Dohlhoff (1857) one, died on fifth day; Pirogoff (1837) three, one death; Hatton (1842), one, hemorrhage twenty-second day, death; O'Shaughnessey (1843), one, hemorrhage tenth day, death; Rossi (1844), one, death sixth day; Campbell (1845), one, death on nineteenth day; Heath (1865), one, recovered, died 1869, ruptured; Hutchison (1866), one, died in forty-one days; Hewson (1867), one, died in twelve days; Mennder (1867), one, death fifth day; Hodges (1868), one, hemorrhage eighth day, death; Sands (1868), one, lived thirteen months, improved; Holmes (1870), one, hemorrhage on fifty-seventh day; Durham (1872), one, death sixth day, shock; Doughty and Mott (1875 and 1876), one, recovered, lived several years; Eliot (1876), one, death twenty-seventh day; Wier (1876), one, death on eleventh day, hemorrhage.

From 1878 to 1896 there has been one case of aneurism of the innominate artery treated by ligation of common carotid and subclavian arteries. Of seventeen cases treated by ligation of the common

carotid, twelve died from operation and two were cured.

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Aneurism of the subclavian was first treated by ligation of the common carotid by Liston (1838). Only three operations of this character were made for this purpose before 1878.

The origin of the left subclavian and its direction explain why it is rarely affected.

Liston (1838) reports a case of ligation of this character which died on the thirteenth day. Parker (1863) did one, resulting in death from hemorrhage on the forty-second day, and Mott (1868) one in which the patient lived but twenty-three days, and died as the result of pulmonary hemorrhage.

Common Carotid.—The position of the left common carotid brings it third in frequency, being only involved with the innominate.

Aneurism of the common carotid artery was first treated by ligature by Coates (1816), who ligated the common carotid for aneurism within it, with death on the seventy-first day; Lyford (1818), one resulting in a cure. Bush (1827) reports one cured by ligation; Cooper (1840), one resulting in cure. Hunter (1843) also reports one resulting in a cure.

Von Balassa (1844) and Ballingal (1854) each did so for the same purpose, and with the same result; Sands (1871), one resulting in cure, with slight paralysis upon right side; and Frothingham (1875) reports one cured, but voice permanently impaired.

Aneurism of the aortic arch and innominate artery was first treated by ligation of the common car-

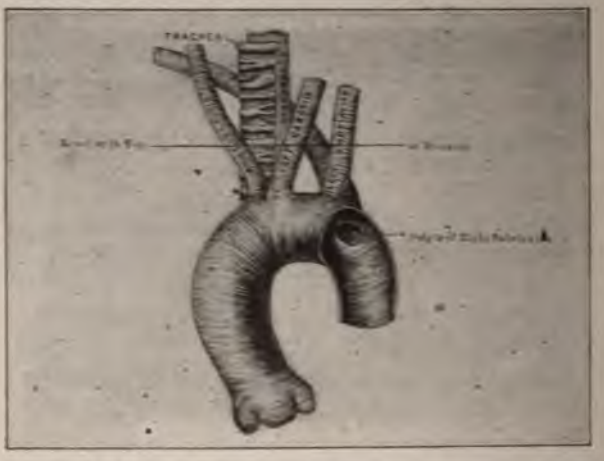

FIG. 8.—Arch of the aorta. Relations of the great vessels when the right subclavian is derived from the descending portion of the arch. (Reduced from a life-size drawing.) (Wyeth.)

otid artery by Bickersteth (1864). There have been but three operations of this character made for this purpose before 1878.

Ensor (1874) did one, but death ensued on the sixty-fifth day as the result of hemorrhage, and Little (1876) had one to recover, the patient being in excellent condition at the end of more than a year.

Aneurism of the innominate and subclavian arteries was first treated by ligating the common carotid artery by Ferguson (1841), and it is the only one made before 1878. Death resulted on the seventh day from pneumonia.

Aneurism of the common carotid, innominate and subclavian arteries was first treated by ligation of

the common carotid artery by Malgaigne (1845), but only two such operations were made for this condition before 1878. The second was by Porta (1842), death resulting within forty hours.

Aneurism of the innominate and common carotid arteries was first treated by ligation of the common carotid arteries by Evans (1828), and resulted in a cure. This is the first recorded case of ligation of the common carotid artery for aneurism of any of the thoracic vessels, and it is the only one made before 1878.

Aneurism of the aorta, common carotid, subclavian and innominate arteries was first treated by ligation of common carotid by Barwell, August 14, 1877. Patient recovered, much improved, November 13, 1877. Distal subclavian was tied at the same time in third division. Patient walked two miles on November 22, 1877, through some sleet and ice, thinly clad, sat four hours in wet clothes without fire, and died November 24, 1877. Autopsy: Innominate right common carotid and subclavian were obliterated, no vessel opening out of the aneurism, which was diminished in size and consolidated. Though many aneurisms of this character have no doubt been treated by ligation of the common carotid and subclavian, this is the only one verified by autopsy.

Filipuncture.—Wire has been inserted into the sac without opening the chest, but it would be more rational to do it after the chest has been opened, because the character of the aneurism can better be determined and the dangers of the wire entering the main arterial channels better avoided.

A small hollow needle is introduced through the first, second or third right or left intercostal space into the sac. A few drops of blood are permitted to escape. A No. 37 gold, silver or annealed steel wire is then introduced through the needle into the sac; when a sufficient amount has been inserted it is cut and the end forced into the sac with a thrust of a square-pointed stylet. Catgut was substituted for wire in one case.

The amcunt of wire depends on the size of the sac. As much as sixty feet has been introduced. One or two milliamperes of electricity may be applied advantageously in producing coagulation of the contents of the sac.

The size of the wire should be but slightly less than the lumen of the needle, and the entire operation should be conducted under strict aseptic principles.

The point of puncture of the cutaneous structures should be covered with adhesive plaster.

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Compression is done by directing force upon the vessel proximally or distally to the sac, or upon the sac itself, to cause coagulum within the aneurismal sac. It may be done with the finger or with mechanical devices such as will cause partial or complete occlusion of the lumen of the vessel or sac, so that both the pressure and the amount of blood flowing through them may be lessened.

Wyeth (1878) says that "direct pressure upon the sac, with venesection, rest in bed, restricted diet and determination of both patient and operator, is the surest success as compared with all known methods of treatment," and that "ligature is second best."

Direct pressure upon the sac, 5 cases, cured 4, died 1.

Massage.—There have been six cases treated by massage before 1878, three of which were cured. Another was cured by Dutoit, by the injection of ergotin around the sac subcutaneously, and digital compression, and still another by Poland, by digital proximal compression. Death from exhaustion followed such pressure in one case, and Verneuil obtained improvement in a case by this method. He condemns the introduction of wire, horsehair, acupuncture, galvanic puncture and injection into the sac, pressure on cardiac or distal side, and massage.

Subclavian—Valsalva's method (more or less

modified), 14 cases, cured 7; improved and in process of cure when lost sight of, 2; 5 died; no venesection in 4 of 5 fatal cases; 1 successful case modified by direct pressure.

Aneurismorrhaphy of distal vessels having been successfully accomplished, there should be no hesitancy in applying it in further attempts to cure internal aneurisms that have not been or cannot be cured by other methods. Continued experimental cardiovascular surgery will sooner or later determine the necessary technique. It will no doubt prove the assertion that the aortic blood current may be successfully diverted from the proximal to the distal end through one or more distal tubes while aortic aneurismorrhaphy is being done.

Positive pressure by means of the vacuum chamber may be a valuable adjunct in doing intrathoracic surgery. It has already given evidence of efficiency, but sufficient work has not been accomplished with it to warrant the statement that this character of intrathoracic surgery cannot be done without it. Too much was done before its discovery to warrant such a statement.

Exploration of the heart with the aorta and its vessels may be made, first, to determine the character of their lesions. This is not an impossibility, and should be done in all cases in which suture or the introduction of wire is contemplated. With the proper technique this should not be any more awe-inspiring than many other operations.

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The selection of an anesthetic is of the greatest importance, whether it should be by inhalation, spinal or subcutaneous injection must yet be determined. Chloroform is probably the one of choice, as the solution of the question now rests. Surely

the one causing the least excitement, struggle and vomiting, would be preferable. Ether vapor mixed with air injected into the lungs by means of a tube inserted into the trachea has been found to be best of all methods for intra-thoracic surgery. Respiratory function may be maintained indefinitely without expansion and contraction of the lungs.

Pre-operative treatment, such as will add to the resistance of shock and lessening of arterial tension,

FIG. 9.—Sacculated aneurism arising within the sinus of Valsalva and involving the interventricular septum (Gibson).

is a most important factor in vascular surgery of this character, and, when possible, should always be instituted for a considerable length of time, and should include the preparation of the patient for immediate operation and whatever constitutional treatment may be indicated, especially that for syphilis.

Technique.—The removal of the manubrium, after separating or dividing the ends of the clavicles and costal cartilages with forceps, may be easily accomplished by an osteo-periosteo-cartilaginous flap to the right or left. This will expose the heart, aortic arch and its branches sufficiently for a most satisfactory examination of them. If necessary, one

or both clavicles may be divided in their middle and retracted upward, if this movement cannot be made without it.

The size of the opening may also be increased by again severing the costal cartilages or ribs on one or both sides.

The internal mammary arteries should be well secured by catgut ligature, and the bleeding intercostal vessels closed in the same way or by forceps. The application of forceps or small catgut should be used upon all of the smaller bleeding vessels, and the exposed surfaces kept dry with gauze.

Whenever the *pleural cavity* is opened, a collapsed space and inflated with air or warm water, preferably water, until the lung or lungs are securely retained within the pleural cavity during the time consumed in the operation. If necessary, one or more such bags may be introduced into one or both of the free pleural cavities, as their presence will not seriously interfere with respiration, even though one-half of the lung capacity be at rest during the time necessary to complete the work.

It is essential that no spicules of bone or cartilages be present, because of the danger of penetrating the bag. This danger, however, might be somewhat lessened by the use of a rubber bag covered with silk.

The same mechanical principles apply to it as apply to the bladder or rubber bag that is inflated with air, water or gas in a tube during the repair of a joint.

Clamps, right-angular in form, mounted with rubber tubing, may be applied to the aorta longitudinally without closing the lumen of the vessel. The blood could by this means of clamping continue to flow in part during the procedure of suture, but it could not do so with the clamp applied transversely.

The effects upon the heart by the transverse application of clamps to the aorta, especially the thoracic aorta, have not been observed. How long it would continue to beat is uncertain; it would probably cease at once. It might do so for a greater

length of time if the vena cava were included within the aortic clamp, for the amount of blood to pass through the heart would probably then be equalized.

With the costal and visceral pleura firmly blended by adhesions sufficient to obliterate the upper thoracic cavity, less difficulty will be encountered in

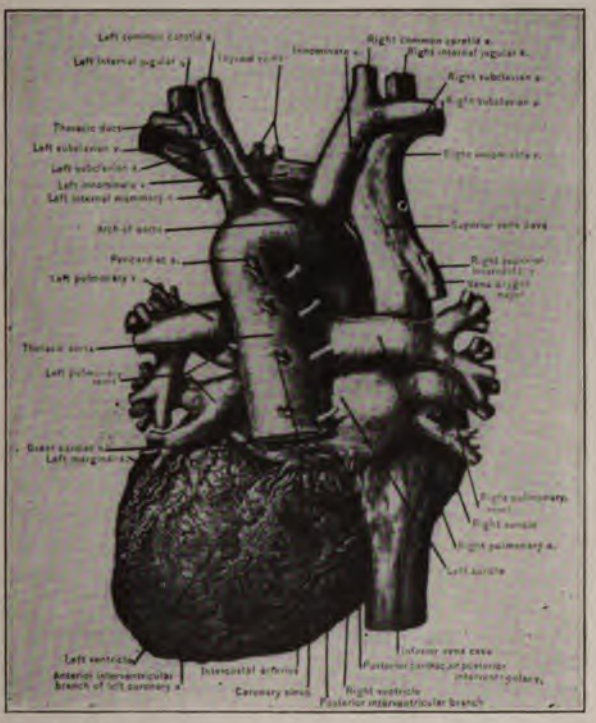

FIG. 10.—Posterior view of the heart and blood-vessels (Deaver).

maintaining respiration while the work is being prosecuted. Such a pathologic condition will, however, add somewhat to the difficulty of doing the work. In the main such adhesions are advantageous with this as with many other intrathoracic operations.

Transfusion into any vessel temporarily out of the cardiac circle can be done successfully in many cases, and this seems an opportune place to do it.

May it not be possible to divert the blood from the proximal to the distal end of the aorta or its branches through a series of tubes, while clamps are applied transversely to the vessels? Is it impossible to carry the blood directly from the tricuspid valves or proximal end of the aorta to the distal end through such a tube or series of tubes to any portion even of the abdominal aorta? There should be no reason why the heart should not continue to supply a sufficient amount of blood through such a tube or series of tubes, even though but one-half or two-thirds of the normal amount could be forced through them. The blood may be taken directly from the left ventricle by means of such a tube, by inserting the needle through the ventricular wall.

Transplanting arteries has made it possible to lengthen one or both subclavian or common carotid arteries, thereby making it possible to supply them from a much greater distance from the heart than normal. One may be made to supply the other by grafting or anastomosis.

Punctures made in the vessel for the introduction of cannulæ or other purposes, may be quickly and securely closed for temporary purposes with fine rat-tooth forceps. Punctures made by such teeth, unless penetrating, will be harmless, otherwise they may be more or less annoying. Mechanical retaining forceps are preferable to finger-retaining forceps for this purpose, and fine needles and silk should always be used for such vessel suture. The sutures should be interrupted from one-eighth to one-sizteenth of an inch, and all bleeding points should be made dry with gauze.

The *vis a tergo* of the blood entering a sac through a small opening from the vessel is greater than that of the blood escaping from the same sac through the same opening into a vessel from which it first escaped, because the pressure resulting from the contractility of the sac is less than that of the cardio-arterial pressure. This difference in pressure continually exerted upon the sac wall from within is probably the cause of the increased caliber of the

sac. The law governing fluid pressure obtains with blood. The pressure of the blood within the sac is equalized by that of the blood within the artery, but the rate of the current within the sac is less. This lessened rate is the cause of coagulum so often within the sac, and which is so often the cause of consolidation of its contents. Circulatory activity of the volume of blood within the sac is proportionate with the size of the opening in the sac—less with small and greater with large openings.

Resuscitation is so satisfactorily accomplished in so many different ways that it may prove to be a valuable adjunct in doing aortic surgery. A method that will be certain to cause the heart to resume its function after it has been arrested for the purpose of giving time to suture an aneurismal opening, is probably not impossible, and may yet be discovered.

Transplanting segments of the aorta may also add further accomplishments in aortic surgery. With more successful methods of resuscitation and implantation, together with improved general technique, why should aneurism of the aortic arch or its branches, one or all, not be successfully repaired by suture or otherwise?

Post-operative treatment necessitates the continuation of the conservation of energy and lessened blood pressure for several weeks. Upon the completion of the aneurismorrhaphy, the air or water may be permitted to escape slowly from first one bag and then the other, each bag to be carefully withdrawn when empty. In the absence of bleeding of any character, the thoracic opening is readily closed. If, however, the lungs should not expand at once, the hand may be placed over the opening in the thorax until they do so, and the opening be kept closed by the hand of an assistant until the flap or hard structures are replaced and firmly secured by wire permanently or temporarily adjusted, kangaroo tendon being preferable. A bit of tape may be inserted at the lowest incised point behind the sternum for gravity drainage. The cutaneous structures are then replaced, with the point of the tape

extending through them. A compress should be adjusted over the entire incised area and held in position with firm pressure by adhesive plaster. With dorsal recumbency, every precaution should be directed toward the prevention of vomiting, hiccough, and sudden movements of the body or extremities. If necessary, straps should be employed for restraint. The head should not be elevated, and the bowels should not be evacuated for several days. The food should be simple, but nutritious, and all excitement avoided.

What the limitations are for suturing aneurisms in the aortic arch and its branches can be determined by the same aggressive surgery that has surmounted so many other difficulties. The size, shape and location of the opening and sac, one or all, will have much to do with securing successful results; the more available will naturally be the first to be remedied, but those least so will in due course of time give up their identity to a successful surgical attack.

What improvements have been made since 1878 to change the conclusions based upon the results of the various methods, both medical and surgical, employed before that time for aneurism of the arch and its branches!

The proper case, time, place and operator are all that is necessary to accomplish this, as has been accomplished with many other seeming impossibilities. When these four essential elements for success will be combined cannot be predicted; surely, however, before the expiration of many more decades. The illustrations are reproductions from Wyeth, Deaver, Gibson and Babcock, and a few of the skiagraphs by Dr. Sidney Lange.

A pathologic condition might preclude the possibility of accomplishing the same results that could be accomplished with a non-pathologic condition.

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BLOOD-VESSELS.*

AORTA.—INNOMINATE.—INTERCOSTAL.—MEDIASTINAL.—INTERNAL MAMMARY.—PULMONARY ARTERY.—PULMONARY VEIN.

Surgery of the thoracic blood vessels other than for aneurysm of the aortic arch and its branches is herein mentioned, the veins being given the same consideration as arteries, though they are not especially mentioned, except the pulmonary vein.

With the exception of the bibliography appended to the chapter on Surgery of Aneurysm of the Aortic Arch and Its Branches, there are none to add to this chapter, thus demonstrating that cases of surgery of the smaller intrathoracic vessels have been few indeed. For technique, see the above-named chapter.

Internal mammary arteries are accompanied by veins originating from the first part of the subclavian artery, but they are divided into cervical and thoracic portions. The latter is the only portion to be considered at this time, and they pass almost directly behind the clavicle downward and one-half inch from the sternal margin to the sixth interspace, where they divide. The thoracic portion therefore originates with the first and ends with the sixth interspace.

The second interspace is most desirable for ligation of these arteries, though it may be done through the first and third.

Ligature of the inferior vena cava.—Bejan and Cohn (*Revue de Chirurgie*, March, 1911) state that if the ligature is performed below the opening of the renal veins, perfect health may result; if the ligature is made at the level of the renal veins, including one of them, toleration occurs, circulation being established through anastomoses; ligature immediately above the renal veins and including, usually, the left,

*An illustrated lecture delivered to students of the American Medical College, St. Louis, Mo., March 16, 1911.

is also compatible with life and even with excellent health; in the writer's experience every ligature made above the right suprarenal has been followed by a fatal result.

Obliteration of the vena cava superior by pressure of a mediastinal tumor has been observed, in a few instances, collateral circulation being sufficient to maintain life indefinitely.

Thoracic aorta.—No attempt has been made to suture wounds of aorta, except experimentally.

Experimentally, gradual automatic occlusion of the larger vessels has been successful in the hands of J. M. Neff (*Jour. Amer. Med. Assn.*, pp. 700-709, Aug. 26, 1911). This method will probably be shown to be of great value in the treatment of the thoracic aneurysm. His remarks are as follows, concerning clamps of his own device:

Application.—The application is exceedingly simple. The clamp and rubber bands are sterilized by boiling, and No. 1 plain sterile catgut is wrapped in the end groove of one of the blades. This must be carefully done, three or four layers being placed one on the other in the groove. The ends of the gut are then tied together as closely as the catgut will permit. If the pulsation distal to the clamp is markedly weakened, the latter is removed and two or three layers of gut wrapped in the end groove of the other blade. The clamp is again applied to the artery, and two turns of No. 9 dental elastic band are placed around both blades in the groove. A section of small-sized rubber tubing or a single turn of No. 9 elastic band is slipped over the hinged end, the muscles and fascia then sutured with catgut over the clamp and the operation is complete.

Modus operandi.—The principle underlying the action of the clamp is the gradual absorption of the catgut between the ends of the blades and the consequent gradual automatic approximation of these blades by the elastic bands. The artery in the grasp of the clamp is necessarily gradually occluded as the blades come together, the occlusion taking place so slowly that the collateral circulation has an opportunity to

develop. After the catgut has completely absorbed and the blades are together, all tissue in the grasp of the clamp undergoes pressure atrophy and is absorbed. This we consider an ideal result: the vessel cut in two and occluded by the clamp, each of the ends tapering to a point and united by a cord of firm fibrous tissue.

Spondylotherapy (*Abracus*).—Boyd (*N. Y. Med. Jour.*, Oct. 21, 1911).

In the *British Medical Journal*, July 8, 1911, Dr. Albert Abrams, of San Francisco, reports forty cases of aneurysm of the thoracic and abdominal aorta treated by his method of concussion of the seventh cervical spine. His method is practically a specific in a disease which has heretofore baffled our best efforts, and it creates an epoch in therapeutical medicine and elevates physiological therapeutics to a place of distinction in the armamentarium of the physician. The results of the discovery have been achieved in a few weeks, and some of his patients were seen, after three and four years, with absolutely no recurrence of symptoms. All of his cases were far advanced in the disease. Dr. L. St. John Hely reported a case of aneurysm of the thoracic aorta (*Medical Record*, May 21, 1910), treated by Abram's method. The aneurysm had perforated the wall of the chest. Within one week all the symptoms disappeared, and fourteen months after the patient's discharge he was as well as at the time of dismissal.

I shall not endeavor to detail the author's method of cure nor its rationale, insomuch as both are exhaustively discussed in his book, Spondylotherapy.

The following is the history of a patient with aneurysm of the thoracic aorta, showing symptomatic cure after treatment lasting about two weeks.

Mrs. H., aged thirty-one years; duration of symptoms, three years. Subjective symptoms, precordial pain, radiating to head and left arm. The painful paroxysms were accompanied by great prostration. Dyspnea was constant, and, like the pain, was accentuated by exertion, emotions or great altitude. There was a troublesome dysphagia, insomnia and dysphonia. Objective symptoms: Moderate exophthalmos, vascu-

lar engorgement of face, neck and hands, notably on the left side. The right radial pulse was retarded and weakened. There was a slight bulging of the anterior chest wall corresponding to the first and second intercostal spaces on the left side, and a marked area of dullness on percussion. The latter dullness could be made to contract or enlarge in area at will by elicitation of the aortic reflexes. (This is an important diagnostic aid in differentiating the dullness of aneurysmal from the dullness of other causes.)

Palpation yielded a slight systolic thrill over the area of aneurysmal dullness. A loud systolic bruit was heard over the aneurysmal dullness, which was propagated posteriorly along the course of the descending aorta. There was an accentuated second aortic tone. The heart was somewhat displaced to the left and the apex beat was diffused over a large area and diminished in force. Slight tracheal tugging was present.

Treatment was administered twice daily and commenced on July 2, 1911, and continued until the 17th of the same month.

The following notes are based on an examination made August 8, 1911:

Subjective symptoms: Absolutely no pains of any kind. Dyspnea, dysphagia and insomnia have disappeared. The voice is practically restored and the patient expresses herself as being highly gratified with the complete relief from previous agonizing physical suffering which this treatmnt has afforded.

Objective symptoms: No exophthalmos or vascular engorgement of the head and extremities. Right radial pulse no longer retarded and restored to normal. The bulging of the anterior chest wall is still present, but diminished. The former aneurysmal area of dullness is fairly resonant, but not completely so. The latter may be attributed to the induration of the chest wall contiguous to the site of the aneurysm. There is no longer any accentuation of the second aortic tone, and the systolic thrill and bruit have disappeared. The apex beat is not diffused, but circumscribed, and has regained its normal position. The tracheal tugging

persists. Improvement in strength and general appearance of well-being still continue.

There was no X-ray verification of the condition in this, but the physical signs respecting the aneurysm and the results of treatment were absolutely positive and unmistakable.

While there is no desire to question the statements of Abrams, much doubt exists about his method being a curative measure for aneurysm of the arch of the aorta. His statements have not been fully verified.—B. M. R.

Blood vessels of smaller variety are subject to many varieties of surgical repair. There is hardly an exceptional cause for death due to hemorrhage, if surgical principles are applied early enough, with proper care. Complications such as arise with hemorrhage and infection are not infrequent, but without them the aftercare is minimized. With all operations upon blood vessels, recumbency and quietude should be maintained for several days; coughing, sneezing and all sudden motions should be avoided, if necessary with the use of an opiate.

Thromboangitis occurs in the larger arteries and veins, causing them to become obliterated to a considerable degree, as when due to infectious diseases such as typhoid fever, etc. The obliteration is due to red obturating thrombi, which become organized, vascularized and canalized, and they are not secondary to gangrene. It occurs more frequently in arteries, but whether in arteries or veins there is a disposition to organize and establish collateral circulation.

Syphilis has been suggested as the cause, but this has not been proven, so that its etiology remains undiscovered. Buerger and Kaliski have collected eighty cases, with only two having luetic infection.

Indications for surgery.—Ligation; arteriorrhaphy; arteriotomy; compression.

Ligation may be required before or after severance through an incision made for this or other purposes. Secondary hemorrhage may occur with or without existing infection, but when they do not occur as complications the treatment is simple.

Compression of blood vessels for various purposes has been done in many ways throughout the history of man, especially for hemorrhage.

Matas and Allen (*J. A. M. A.*, vol. lvi, No. 4, pp. 233-239, Jan. 28, 1911) relate their experiments with arterial compression. They have demonstrated that the lumen of femoral arteries of the dog may be obliterated by clamp for seventy-two hours without permanently destroying the lumen.

Christian Fenger ligated the right external carotid artery for hemorrhage due to gunshot wound through the base of the skull without avail. He then ligated the left external carotid with the same result. He then applied a temporary ligature upon the right common carotid, but bleeding continued. A temporary ligature was then applied to the left common carotid, but bleeding continued. Not until he permanently ligated the right vertebral artery did hemorrhage cease. The temporary ligatures upon the common carotids were removed at the end of one hour and twenty minutes, but the ligatures applied to the two external carotids and right vertebral were left undisturbed. The patient made an uninterrupted recovery. It has been demonstrated, on dogs, that both external and common carotids and the two vertebral arteries may be permanently ligated without fatality. The deductions from these facts are that any artery may be temporarily excluded for surgical purposes.

Both venae cavae may be closed, close to the heart, for several minutes without death resulting. This also obtains with the pulmonary artery.

My own experience with reference to ligating the carotid and vertebral vessels in the dog corroborates that of others. Halsted and Crile have done much to advance the technique of cardio-vascular surgery.

Indications for ligation.—Lacerations; incisions; puntures; aneurysm and hematemesis.

Incisions, intentional or accidental, vary in extent and location, and are partial or complete to severance. It may be necessary to enlarge the opening in their overlying structures for ligation with or without exist-

ing infection. When not complicated by infection or hemorrhage the treatment is simple.

Punctures vary in degree and shape, and when not large enough to suture it is impossible to do so in small vessels, both the proximal and distal ends should be ligated, if necessary enlarging the opening in the overlying tissues, complications seldom arising unless infected.

Aneurysms, when treated by proximal or distal ligature, or both, usually require but little after-care in the absence of infection; otherwise grave dangers are to be apprehended, because of secondary hemorrhage and gangrene. When treated by any method perfect quietude should be maintained for ten days in a recumbent position.

Arteriorrhaphy has become a most favored and useful surgical procedure for closing openings in blood-vessels. The vessels that most frequently require it are the innominate, aorta and subclavian. These, however, have not as yet been attacked, but it is a surgical possibility, and may become a reality at any time; and, when not complicated with infection, hemorrhage or gangrene, are easily and safely cared for.

Indications for arteriorrhaphy.—Punctures, incisions and lacerations.

Punctures of vessels are of many varieties and degrees. As a rule, with the smaller vessels, a compress will check bleeding. When it does not do so with small or large vessels, an incision through the overlying tissues is necessary, but they do not cause any complications. The dangers are usually insignificant, and the after-care of no great importance.

Incisions of veins and arteries are done for the removal of clots and foreign bodies, the insertion of tubes and needles, and for the introduction of fluids. They are also done for anastomosis, lateral, or end to end. Incisions having been necessary to accomplish these, it is sometimes better to provide for drainage. However, such are less frequent, and the after-care simple.

Lacerations of blood-vessels sometimes necessitate ligation, sometimes torsion, sometimes compression

alone, and sometimes nothing at all. In either instance such wounds are easily infected, and, when so, require considerable after-care.

Arteriotomy is usually done longitudinally, but may be transverse. It is for the introduction of a cannula, or the removal of clots, sometimes for depletion. If the vessel is small, or the opening in a large vessel is small, a compress will usually control bleeding, but if complicated with infection or secondary hemorrhage, ligation becomes necessary, and the after-care more important.

Indications for arteriotomy.—Depletion; transfusion; anesthesia and medication.

Depletion.—Veins are usually selected for this purpose, but small arteries permit of more rapid flow for great emergencies. The vessels of the forearm are most frequently selected, and without complications nothing more than the application of a firm compress with bandage for three or four days will be required.

Transfusion.—It is necessary to open a vessel that a cannula may be inserted for the introduction of fluid into the vascular system. It may be into a vein or artery, preferably an artery in the forearm. If into an artery of any considerable size ligature may be necessary. If the artery is small, a compress with bandage will suffice. Complications in such cases are rare.

Anesthesia.—A needle may be introduced into a vein and cocaine injected through it, to produce anesthesia without incising the overlying soft structure, because the vein becomes prominent after a bandage has been applied above and below the point of entrance. Usually a strip of adhesive plaster applied firmly will prevent bleeding without complications.

The after-treatment pertaining to ligation of the thoracic vessels is sometimes exceedingly complicated, because of the disadvantage of drainage, should it become necessary at, or subsequent to, the primary operation. Drainage then should be with reference to gravity, and every precaution taken to prevent further infection of one or more of the thoracic viscera. Drainage should be done in the same way as that for the

pleural cavity for any cause. If not infected there will be no need for drainage, and the wound may remain undisturbed until repair is complete. Recumbency and quietude together with moderate nutritious diet are always essential.

Should the innominate artery be ligated through the neck and drainage necessary, the secretion need not enter the pleural cavity. Neither would it be necessary for such fluid to enter the pleural cavity if this or the common carotids be ligated beneath the sternum after it had been removed. Wounds of such character should be treated similar to wounds in the soft structures of other parts of the thorax.

The after-treatment of arteriorrhaphy and arteriotomy is the same as that for ligation.

ANEURYSM.

ANEURYSMORRHAPHY—INTRODUCTION OF WIRE—LIGATION—COMPRESSION.

Aneurysmorrhaphy may be necessary in any thoracic vessel, though it may be rare except in the ascending, transverse and descending aorta. While aneurysms of the thoracic vessels have not been treated successfully except by the introduction of wire and deligation of the common carotid and subclavian, it is sincerely predicted that some other means of cure will yet be discovered, now that the means of intratracheal insufflation has been discovered.

Aneurysmorrhaphy (Matas) is one of the most modern and skillful operations and the one of choice when location will permit. Drainage may or may not be necessary in the thorax. Carrel severed and anastomosed the thoracic aorta in a dog while anesthetized by intra-tracheal insufflation, but such a procedure has not been reported in man.

Introduction of wire (Moore's operation) into aneurysms of the thoracic aorta has been successfully accomplished a sufficient number of times to warrant its continued use. It is indicated when suture can not be applied. Many yards of a small silver or annealed steel wire are introduced through a cannula inserted

into the aneurysmal sac. One or two milliamperes electric current (galvanism) is then passed through the wire to coagulate the blood contained within the sac. The treatment is quietude, restricted diet, and eternal vigilance. With proper precautions infection need not occur. The introduction of wire into an aneurysm of the aortic arch was first done by Mr. C. H. Moore, of Middlesex Hospital, London, 1864. To Loreta has been given this honor, which he does not deserve. He does, however, justly claim the credit of having been the first to apply an electric current to the wire after it had been introduced into such a sac. It is, therefore, fitting to call the combined methods the Moore-Loreta operation. It was our pleasure to witness the introduction of gold wire into an aneurysm of the abdominal aorta by Dr. Francis T. Stewart at the Philadelphia Hospital during the Congress of Surgeons, November, 1911.

Ligation, proximal or distal, or both, for aneurysm has been a favored operation for many years, and can only be done through an incision in the over-lying soft parts, usually made for the purpose.

Deligation of the common carotid and subclavian arteries for aneurysm of the aortic arch has been done by the writer in six cases, with most gratifying results in the majority of cases, all having recovered from the operation, to die weeks, months or years after. If done rapidly and without infection, the after-care is simple.

Compression for the cure of aneurysm has been done innumerable times, more or less successfully, by digital and various other ways to limit forcible pressure upon the proximal portion of the artery. There is no special after-care, other than that given during the time of applying the pressure, which should be continued more than one hundred hours.

Concussion.—Recent reports to the effect that aneurysm of the thoracic aorta has been cured by producing daily concussion for several weeks upon the seventh dorsal vertebra, have excited considerable interest, and it may prove to be a rational method for the care of aneurysm of any artery. Possibly the

electric hammer will prove to be the best means of producing clot by concussion.

Treatment for compression for aneurysm of the thoracic vessels is recumbency, quietude, moderate food, sedatives and injections of gelatine into the buttock.

Treatment of ligation of thoracic vessels for aneurysms.—See treatment in aneurysmorrhaphy.

Surgery of the pulmonary artery.—Dr. Willy Meyer, New York (*Jour. Amer. Med. Assn.*, June 21, 1913): The main trunk of the pulmonary artery is easily accessible within the pericardium after incision of the latter and pulling the pulmonary artery plus ascending aorta forward by means of an elastic tube, which is conducted through the transverse sinus of the pericardium. The elastic tube compressing both vessels is held by an assistant, the pulmonary artery is incised, and the emboli are removed with forceps. The vessel wound is then closed by sutures. Trendelenburg and his assistants have done the operation twelve times. No permanent recovery has been seen so far, but the results are encouraging. One patient of Krueger lived four days after the operation and then died of pleuropneumonia. The two arteries can not be compressed longer than forty-five seconds. Laewen and Sievers of the Leipsic clinic have found that the compression of the two venae cavae is better borne, evidently on account of avoiding the distention of the right heart. In doing this, six or eight minutes are at the operator's disposal. The ligation of branches of the pulmonary arteries for bronchiectasis was recommended by Sauerbruch and Bruns two years ago. Three patients operated on by me are greatly improved so far. The interruption of the physiologic function of the lobe of the lung produces shrinkage, connective tissue formation, and adhesion between pulmonary and costal pleurae. Multiple resection of ribs done at a second stage produces collapse of the lung later on. The main trunk of the left and right pulmonary arteries can be ligated without harm in the animal. The left branch is nicely accessible within the pericardium by reflecting a part of the latter or right

outside of the pericardium, according to anatomic conditions. Ligation of the right branch is more difficult. The best procedure is the exposure and ligation of the right pulmonary artery within the pericardium between the ascending aorta and the superior vena cava. Another approach is to the division of the right pulmonary artery through an incision outside of the vena cava superior. The experimental work on the latter approach has not yet been completed. If it should be shown that pulmonary shrinkage and collapse therapy of the lung do not cure or at least greatly improve the trouble, pneumectomy will become the operation of choice, since we have learned to close the bronchus air-tight.

The treatment after the introduction of wire into thoracic aneurysms is usually simple, because the wound is small and non-complicated. The sanitary care of the patient is the same as for suture for aneurysm (see aneurysmorrhaphy).

The after-care of suturing aneurysms of the thoracic vessels consists in maintaining perfect quietude, liquid diet, freedom from vomiting, coughing, sneezing, or any other sudden violent exercise. Recumbency for two weeks, sometimes longer, is necessary. Wounds to the overlying structures, if not infected, repair themselves rapidly with but little attention, but if infected drainage must be perfectly secured and maintained throughout repair. Dressings for such purposes should be changed frequently.

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CHAPTER XIII.

SURGERY OF THE ESOPHAGUS.*

ESOPHAGUS.

(1) Anatomy; (2) Diverticulum; (3) Experimental; (4) Diagnosis; (5) Treatment; (6) Esophagotomy; (7) Esophagectomy; (8) Esophagorrhaphy; (9) Dilatation; (10) Esophagogastrotomy; (11) Pharyngotomy; (12) Tracheotomy; (13) Gastrotomy; (14) Gastrostomy; (15) Esophago-Jejunostomy; (16) Pylorostomy; (17) Gostroenterostomy and Jejunostomy; (18) Bibliography.

The esophagus is constant in vertebrates, varying, however, in its structure and proportions. Its purposes are the same, being the means of direct entrance of food to the digestive apparatus. It is in the median line, anterior to the vertebræ, behind the heart and lung, and parallel to, and in close proximity with the aorta and vena cava.

Embryology.—It first appears embryologically on the fifteenth day, lying immediately above the heart; the mouth and the opening appears on the sixteenth day by perforation of the stomatodeal septum, so that by the middle of the fourth week the alimentary canal is well formed and the esophagus much increased in length by the fifth week.

The calibre of the adult esophagus at the upper constriction is about four-fifths of an inch, but it may be dilated to one inch in diameter. It is less elastic than either the middle or lower constriction, and only six inches from the upper incisor teeth, and opposite the sixth cervical vertebra.

The second narrow point is two and three-quarter

*An address delivered to the students of the Medical Department of the University of Arts and Sciences, St. Louis, Mo., March, 1913.

inches below the cricoid cartilage, and at a point corresponding with a line passing antero-posterior through the middle of the first piece of the sternum, or about nine inches from the upper incisor teeth.

The third constriction is about six inches below the second, or fifteen inches from the upper incisor teeth. The third is the more distensible, and should be approached through an incision in the stomach.

DIVERTICULA.

Normal diverticula of the digestive tract.—Definition: A diverticula is a sack or pouch arising from the main tube. Diverticula of the digestive tract may be normal or abnormal. In this chapter only normal diverticula are discussed. Among the most interesting normal diverticula are the cheek pouches of the pig-tail monkey (*Macacus nermestrius*). The stomach is nothing more than a diverticulum. There is a difference in the shape and number of stomachs present in animals. In the monkey, cat, dog, hog, horse, rat and mouse, one stomach or gastric diverticulum is present. Ruminants have four stomachs; examples are the sheep and cow. In other animals two to three gastric diverticula are present. Typical gastric diverticula are found in some fishes. Such stomachs are found at the bottom of the esophagus of the angler, codfish, dogfish, flounder, salmon, trout, windowpane, eel and haddock. Carnivorous amphibians and carnivorous mammals also have stomachs which are good illustrations of gastric diverticula. Examples are the crocodile and harbor seal (*Phoca vitulina*). Two stomachs are present in the crocodile, one a muscular diverticulum and the other a pyloric stomach. There is no crop in carnivorous birds. The stomach is a good illustration of a diverticulum in these birds. To this group belong the owl and heron (*Order cinerca*).

Occasionally a diverticulum is found in the illeuna. These diverticula are Meckel's diverticula. This, however, would hardly be called a normal diverticulum. If normal, it should be classed as abnormally normal.

A natural diverticulum of the colon is the cecum. Such a cecum is found in the dog, hog, cow, horse,

sheep, rhinoceros, giraffe and elephant. Birds have two ceca or colon diverticula. Examples are the chicken, duck, goose, turkey, ostrich, etc. Esophageal diverticula are normally found in some mammals and birds. In cetaceous mammals a diverticulum is found at the lower end of the esophagus before it empties into the stomach. The apex of the diverticulum points downward, and is on a lower level than the opening into the stomach. This is true in the porpoise.

Birds use great amount of energy, and as a result require much food. Some consume from one-sixth to one-fourth their weight in twenty-four hours. Mastication is accomplished by the crop and gizzard. The crop is a typical diverticulum found in the lower third of the esophagus. It is present in gallinaceous birds. To this group of birds belong the chicken, turkey, pheasant, guinea and pigeon. In the crop the food is moistened and acidified before it passes into the muscular stomach. Crops are absent in birds of prey. Among these birds are the hawk, owl and buzzard.

Insects also have crops; the wasp, honey-bee and beetle belong to this group. Among the lower forms of life, the worm is found to possess a crop.

It is therefore observed that normal diverticula are more or less constant with all forms of life, and that both normal and abnormal diverticula are frequent surgical entities with each.

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Traction diverticulae.—Etiology: Inflammation of the esophagus and surrounding structures causes adhesion between the esophagus and these structures. If the adhesion is at a small point a traction diverticulum results. These adhesions may occur between the esophagus and any one or more of the following structures: Cricoid cartilage, thyroid gland, pericardium, pleura, vertebra, aorta and bronchus. In 80 per cent. of the cases the traction diverticulum is at that portion of the esophagus which crosses the bronchus. (Geo.

Gottstein, Keen's Surgery, p. 813.) This is due to tubercular or other inflammatory or suppurative conditions of the bronchial glands. According to Zeneker (Ziemssen's Encycl. Med., vol. viii, 1878), traction diverticula are funnel-shaped, with their bases down. Going further into the analysis, traction diverticula are only discovered by autopsy.

Pressure diverticulae.—Etiology: Pressure diverticula are due to weak spots in the wall of the esophagus. These weak spots may be congenital or acquired. Injuries which weaken or sever the circular muscular fibers of the esophagus will cause diverticula. These injuries may be caused by foreign bodies or instrumentation. "Degeneration of nerve filaments will in all probability cause diverticula" (D. D. D.). As the food passes through the esophagus it hesitates at these weak points, and because of the internal pressure exerted by the food the esophagus is dilated. As the dilation becomes larger, a pocket or diverticulum is formed. Vomiting is another cause which is of more importance, since a great amount of internal pressure is exerted during this act. The size of the diverticula varies. Luschka reported a case the circumference of which was 30 cm.

Pharyngeal-esophageal pressure diverticula of Zeneker is the most frequent form of pressure diverticula of the esophagus. In one-third of the cases tumor is present. It may be either posterior or lateral. (Sippy. Diagnosis of Ssophageal Lesions, *Annals of Surgery*, vol. xliii.)

Traction pressure diverticula are primarily due to traction. The bases of these diverticula are in such a position that food accumulates within them, and from the resulting pressure the diverticula are enlarged. Vomiting occurs, more internal pressure is exerted and more dilation results.

Symptoms, diagnosis and *treatment* are considered under pressure diverticula.

Complications.—Inflammation, ulcer, stricture, carcinoma, foreign bodies and fistula may complicate esophageal diverticula. Perforation due to ulcer, foreign body or instrumentation may also result. Osler

reports a case of esophago-pleuro-cutaneous fistula with exit at right inferior clavicular region, which had existed for twenty years. Fistulas may result from perforation within or from without. The causes from within were described above, when due to causes from without tuberculous processes may be the cause, also foreign body causing gangrene or rupture of the bronchus. In a case reported by E. Pachnio (*Archiv. f. Verdauungs Krankh.*, Berl., August 12, 1908, bd. xiv, pp. 369-478), the cicatricial contraction from a tubercular lung caused traction which caused a diverticulum of the esophagus. Later the tubercular lung became active and caused a diverticular fistula. Fistulas may also be caused by gunshot wounds, caries of the vertebra, fractured ribs, etc.

Symptoms of pressure and traction pressure diverticula—Pharyngo-esophageal diverticula.—In this type of diverticulum there are some symptoms not found in the diverticula within the thorax. One of the most important of these symptoms is tumor, which occurs in about one-third of the cases. (Sippy.) In the early morning when the diverticulum is probably empty the the patient will be able to swallow easily. As the diverticulum fills, dysphagia increases, and in far-advanced cases when the sack becomes filled, it may, by its pressure, prevent the swallowing of food entirely. Sometimes moving the head in different directions will enable the patient to swallow. As the meal progresses the tumor may increase in size. As to whether this is perceptible or not will depend upon the size of the diverticulum. Vomiting of food and mucus may take place, after which food may be introduced more easily. If the patient expels the food by pressure, or if the food is washed out of the diverticulum, the deglutition may again be accomplished. If the diverticulum becomes so large as to prevent the introduction of food into the stomach, inanition and death results, unless active interference is made.

Thoracic esophageal diverticula are those diverticula found within the thorax. In these cases the absence of a tumor in the neck will indicate that the diverticulum is probably within the thorax. At first there is

slight distress, as if a foreign body were beneath the sternum. As the diverticulum increases in size dysphagia develops. When the diverticulum is large and filled with food, dyspnea may be present. Food and mucus is regurgitated during or after meals. At times ill-smelling food-casts are regurgitated. The food is found to have undergone no digestive changes, except those accomplished by the saliva. These food-casts are often ill-smelling. The breath is very offensive. Sometimes the smell permeates several rooms. This smell is due to the food changes in the diverticula. Hoarseness may be present or absent.

Diagnosis.—Pharyngo-esophageal diverticula have one point which is of particular importance in its diagnosis, viz., tumor. Some of these tumors may be emptied of their food contents by pressure. When the food has been expelled as described, the diagnosis is positive. The tumor may be found to be hard upon palpation, if food is present at the time of examination. After the food has been expelled less induration would be expected to be present. This, however, will depend upon whether the food in the diverticulum is liquid or solid. Also upon whether the walls are thick or thin.

C. M. Cooper, San Francisco, Sept. 3, 1910 (*Jour. Am. Med. Assn.*, p. 856), records four cases in which the following method was used to make the diagnosis. The patient drinks as much water as he can in the morning, when the diverticulum is empty. The larnyx is grasped by the hand and the soft tissues of the neck vigorously shaken. During this time the ear is placed at the patient's neck, and he is requested not to swallow or breathe; a splashing sound is heard if a pharyngo-esophageal diverticulum is present.

Sounding with bougies.—By this method of examination the point at which the diverticulum is present may be determined. If the bougie meet with obstruction in all probability it has passed into the pocket. By passing one or two more bougies into the esophagus one may be passed into the stomach.

The easiest way of passing bougies is on a thread according to Mixter's method. Six yards of silk thread

is swallowed, and time allowed for the thread to pass into the intestines. A bougie with an eye in it is now passed upon the thread into the esophagus. If resistance is met with by making the thread taut, the bougie may be passed over the obstruction, even if the obstruction is a diverticulum. The advantage of this method is apparent, as the depth of the diverticulum can be estimated.

X-rays are of very great service in the diagnosis and study of diverticula. They are of very great service in that they furnish a record for reference at any time. If operation is decided upon, the skiagram is of greater service to the surgeon.

Bismuth is of very great value in X-ray photography. Seelig, of St. Louis, has found that if the patient swallows a gold chain it is of great advantage in the diagnosis of diverticulum of the esophagus.

Esophagoscopy is advantageous in any disease of the esophagus. By this method of examination the esophagus is inspected.

TREATMENT.

The treatment of esophageal diverticula resolves itself into non-surgical and surgical.

Non-surgical treatment should be commenced early. Every means should be employed to prevent greater enlargement of the sack. Diet is of much importance. Solids should be replaced by liquids. If by assuming certain positions, food can be passed into the stomach, it is evident that the patient will and should take advantage of them.

That good gastric digestion may be secured, or that the diverticulum may be kept in as good a condition as possible, irrigation should be practiced. Lavage will be of service in preventing food from entering the diverticulum, or in prolonging life when operation is not resorted to.

Dilation with bougies may result in improvement. One case has been reported as cured by this method. It does not seem reasonable that a cure can be accomplished by this method. Dilation with an inflatable rubber bulb has been recommended by Gottheissen.

(Behandl. d. Speiserohrendivertikels. *Muench. Med. Wochnschr.*, S. 77, 1906.)

Rectal feeding may be resorted to until surgical measures can be employed.

Surgical treatment is palliative and radical.

Palliative surgical treatment consists in gastrostomy. This is a means of prolonging life or improving the condition of the patient, until radical measures can be employed. Even this operation is often followed by pneumonia. If a radical operation is performed later it is wise to take advantage of the fact, that gastrostomy has been done, and feed the patient through the gastric fistula until after the esophageal wound has healed.

Radical surgical treatment consists in resection, invagination, plastic operations and thorectomy. (See chapters.)

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EXPERIMENTAL.

(Meyer, *Jour. Am. Med. Ass.*, Chicago, December 11, 1909):

"*Gastroesophageal anastomosis without resection.*—The eighth rib is first resected subpereiosteally. The chest cavity is opened in the periosteal floor of the resected rib. The peritoneal cavity is opened through the diaphragm, and the anterior wall of the stomach is drawn into the thoracic cavity. The stomach is opened, the female half of the button is introduced, and the opening closed by a purse-string suture. The male half, which has been previously passed down the esophagus, is now separated from its carrier and supported for engaging the female half. This button, which has been designed by us especially for esophageal anastomosis, and depends for its union on penetrating needles, is then pressed together. The circle of anastomosis is reinforced by a running suture. The portion of tissue between the two halves of the button subsequently sloughs out and liberates the button. The opening through the diaphragm is closed by suturing this structure to the wall of the stomach. Closure of the chest completes the operation."

Experiments upon dogs have demonstrated that the esophagus may be incised, sutured and resected with comparative ease, in the upper, middle and lower portions, so that this channel may now be considered as a surgical entity.

EXPERIMENTAL.

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DIAGNOSIS.

Symptoms.—Cabouche (*Journ. des Practiens*, Feb. 25, 1911) discusses in detail the diagnostic use of broncho-esophagoscopy in mediastinal tumors. He points out that hitherto it has been mainly employed to aid in the extraction of foreign bodies, and is becoming more and more used for the diagnosis and treatment of organic affections of the mediastinum. A number of cases of stricture of the esophagus for which the sole treatment used to be gastrostomy have been healed by dilatation, with or without electrolysis after an internal esophagotomy has been done by the aid of the esophagoscopic tube. Again, many malignant tumors of the esophagus have been detected in quite an early stage, before the ordinary clinical signs had made their appearance. The author quotes several authorities who in these circumstances have practiced resection of stricture and removal of tumor of the trachea under control of the bronchoscope. One of these was the case of a man who for two years had suffered from blood-stained expectoration, and which it was supposed was due to pulmonary tuberculosis. Bronchoscopy showed the trachea to be normal, but in the right bronchus a small tumor was found, about the

size and color of a raspberry, which turned out to be a carcinoma. The author gives in some detail the history of a case of posterior mediastinal tumor examined and diagnosed by this method. The patient was a man of 53 years of age, who for more than two years had suffered from dyspnea, wheezing and intermittent cough, not unlike whooping-cough in character. There was abundant expectoration and deep-seated pain about the middle of the chest. Patient had complained for some time of difficulty in swallowing solid food; it seemed to be arrested at a point opposite mid-sternum. Two years ago the dyspnea was not permanent, but about a year ago he suffered from severe pain, pleuritic in type, in the left side of the chest and since that time it has become constant. Laryngoscopic examination revealed nothing abnormal. There was no dilatation of thoracic veins, no modification of either pulse, pupils were equal, apex beat was in 6th intercostal space, auscultation of right lung gave normal results, but on left side there was complete abolition of vesicular murmur. The hypothesis of anterior mediastinal tumor was not a likely one in the absence of compression of great venous trunks, thus eliminating the probability of hydatid or tumor arising from thymus gland. Broncho-esophagoscopy was decided on after a skiagraph had been taken to remove any doubt as to likelihood of there being an aortic aneurysm. Examination established the fact, that there was a posterior mediastinal growth, which was both extra tracheal and extra esophageal. The tumor was between the trachea and esophagus causing in both passages the pressure and occlusion which resulted in the symptoms before described. (*Brit. M. J., Lond.,* May 6, 1911.)

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TREATMENT.

(1) Medical; (2) Surgical.

Medical treatment pertains to syphilitic lesions that are amenable to mercury and arsenic, malignant neoplasms that may be cured with serum, X-ray and radium, and those conditions that can not be benefited by anything whatever.

Serum offers more than any other remedy in this class, but as it is in the experimental state the subject will not receive further consideration.

Roentgen ray has been shown to be a remedy of much value both in malignant and non-malignant neoplasms and it should be applied before more radical measures are resorted to.

Radium, like the X-ray, has had a decided beneficial influence upon certain new growths, but it has not become a practical means of treatment.

1. *Radium treatment in cancer.*—Einhorn reports six cases of cancer of the stomach, and one of the rectum. He concludes: "If we consider that in all these cases we have to deal with separate conditions, where until now our only treatment has consisted in increasing doses of opium or morphine, we may be contented with the results of the radium treatment. It would, of course, be more satisfactory if I could report a cure. This has, however, not been the case, although the possibility is not excluded. Long continued applications of strong radium may, if inaugurated sufficiently early, be crowned occasionally with entire success. I am, however, ready, on the basis of my experience, to recommend highly the direct application of radium in inoperable cancer of the digestive tract." Einhorn has constructed an instrument for the application of radium to the pylorus. It consists of a radium receptacle with a long whalebone stem; the capsule for the reception of the radium is provided with a small canal on its side, through which a thread can easily be passed. The method of radium application to the pylorus is accomplished in the same manner as the catheterization of the pylorus. The patient swallows, the night previous, either a small duodenal bucket or a metal olive, attached to a long braided silk thread; the length of the thread is such that from 75 to 80 cm. can enter the digestive tract and the end is attached to the shirt. On the following morning, in the fasting condition of the patient, we see whether the bucket or the olive lies beyond the pylorus or in it. If this is the case a slight resistance is felt when we pull at the thread. In the

stomach there is usually no such resistance felt. The thread is now cut near its attachment and drawn through the canal of the capsule and the latter is pushed along the thread by means of the whalebone stem, first into the mouth, pharynx, esophagus, and finally the stomach of the patient, slowly and without exertion of force, until an unsurmountable resistance is encountered. The latter is the strictured place. The capsule of the instrument now lies exactly at the spot we wish to treat with the radium. We, therefore, leave the instrument lie there for one half to one hour, after again attaching the thread to the nightgown of the patient. When the time for the application of the radium has elapsed, the radium holder, the olive, and the thread are slowly withdrawn. Occasionally it is desirable to leave the radium for a longer period (six hours or more) in the digestive tract. It is then necessary to have the radium capsule exactly at the diseased focus. The hard rubber capsule devised by him and attached to a thread would be serviceable, but in swallowing the capsule we cannot tell whether we have touched the affected spot. The whalebone instruments are also unsuitable, because they exert too much irritation in the throat of the patient, if left in for any length of time. He has constructed a "radium introducer". It consists of a spiral metal sound, covered with rubber, and a mandril. For a longer application of radium we use a capsule hollowed out in its upper end. The introducer is inserted into the hollow part of the capsule, the thread is drawn tight and pressed against the rubber tube. In this position the capsule is pushed to where it is wanted (esophagus or stomach). Now the mandril is first removed. This causes the capsule to lie free. Then the rubber of the introducer is slowly and carefully removed. We now have the capsule with the radium at the seat of the disease, and the thread emerging from the mouth of the patient is attached to the clothing. This procedure is not connected with any disagreeable symptoms for the patient, and the capsule can be retained in the digestive tract as long as desirable.

RADIUM.

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SURGICAL (ESOPHAGOTOMY).

(1) Extra-thoracic; (2) Intra-thoracic.

The esophagus may be injured, diseased or contain foreign bodies to such an extent as to require incision, suture, excision or anastomosis. That these may be done, ribs should be excised, or an osteoplastic flap made, unless in the upper third portion, when it will be necessary to approach it through the soft tissues of the neck.

Extra-thoracic surgery includes such operations as are done without opening the thoracic wall. Cervical and abdominal incisions to reach the esophagus are of this character. Intra-esophageal through the mouth and stomach may also be included.

Intra-thoracic surgery relates to operations that necessitate incisions through the thoracic wall.

ESOPHAGOTOMY.

(For Posterior Esophagotomy, see chapter on Mediastinum.)

Esophagotomy may be more conveniently done in its upper and lower portions, but intratracheal insufflation and the vacuum chamber will no doubt prove an effectual means of attacking any part of it. Such wounds are usually infected from their contents, and must therefore be classed as complicated.

It is best accomplished through an incision along the entire anterior border of the left sterno-clavicular muscle. It is necessary to divide the anterior jugular, middle thyroid and accessory thyroid veins, and deep fascia, before the trachea can be distinctly felt. The recurrent laryngeal nerve must now be found between the trachea and esophagus. This, together with the innominate vein, must be dealt with carefully.

Indications for esophagotomy.—Stricture, foreign bodies, neoplasms.

Stricture, when not amenable to dilatation by bougie necessitates division by one of the several methods employed in the upper and lower third of the esophagus. The after-care pertains principally to feeding, and, without complications, is of but little moment.

There are three points where constriction is most likely to occur—above, at the cricoid cartilage; below the diaphragm, and in the middle at a point corresponding with the aorta, and left bronchus. These are the points where corrosives remain longer, consequently are more destructive.

Etiology.—Narrowing of the esophagus may be congenital or acquired.

Congenital narrowing is usually confined to the upper portion of the esophagus; however, it has been observed in a child two and a half years old at the level of the bifurcation. (Geo. Gottenstein, Keen's Surgery, p. 804.)

Acquired stenoses are due to strictures, and are caused by chemical, mechanical and thermal agents or caustics, such as lye, bichloride of mercury and strong acids, etc. Thermal agents may be solids, as liquids. Mechanical means are instrumentation, sword, spear, or bayonet swallowing, foreign bodies, etc.

Diphtheria, typhoid fever, syphilis, tuberculosis, peptic ulcer and *caseation* of bronchial glands are diseases which rarely cause stricture of the esophagus. Carcinoma more commonly produces it than any other disease, while cardio-spasm is also a cause. When stricture is due to any of the etiological causes except carcinoma there has been an ulcer or sloughing of the mucous membrane, or into the deeper structures after the healing of which there was a cicatrix. The cicatrix contracts as does all scar tissue, and forms the structure. Carcinoma encroaches upon the lumen of the tube by the growth of the neoplasm. Peptic ulcer is caused by the corrosive action of regurgitated fluid from the stomach.—Ewald. (Monge's translation of Diseases of the Stomach, p. 115.)

Caseation of bronchial glands because of their ac-

tion externally to the esophagus, causing inflammation, perforation, etc., cause strictures of the esophagus.

Symptoms.—About four to six weeks after a caustic has been swallowed, dysphagia may develop. This is manifested by the lowering of the chin, or turning the head from side to side during deglutition. Later mucus and blood are regurgitated together or singly. When liquids are regurgitated it may be preceded or accompanied by a gurgling sound.

Before obstruction becomes complete, periodical spasm may occur, but when the spasm occurs food and mucus are regurgitated. This spasm may last for only a short time, and it may or may not occur several times in twenty-four hours. When the obstruction is complete, if liquid is taken it may remain for a few minutes before it is regurgitated. This is especially true when there is an obstruction at the cardia. HCl is absent in the regurgitated fluids.

Ausculatory symptoms.—Metzei's sign is absent when the stricture causes a complete obstruction.

Another valuable sign: When a patient swallows water, some is retained above the stricture; if then the patient swallows, again some of the water will pass into the stomach, causing the second sound. This second sound will be produced after each act of swallowing until all the water possible has passed into the stomach. (P. M. Revidtzev, Moscow; *Semaine Medicale*, Paris, Feb., 1908. Signe non encore decrit des retrecissements de l'esophage.)

Bronchitis frequently accompanies stricture of the esophagus; when the stricture is complete or partially so, anemia develops, and under such circumstances the patient suffers from intense hunger.

Diagnosis.—If there has been a history of chemical, thermal or mechanical injury to the esophagus, with dysphagia following in four to eight weeks or later, the probability of stricture is very great. When the patient is thirty years of age or older the probability of mediastinal tumor or carcinoma of the esophagus and all other causes due to outside pressure are to be considered. Cardio-spasm may be differentiated by Schroder's method, which will be considered under

esophagospasm. When disease has been the cause of stricture, the diagnosis may be more difficult unless the methods to be described are used.

Roentgenography.—By the use of bismuth mush and a capsule the diagnosis of stricture of the esophagus can be made before obstruction or dysphagia develops. (Lange.)

Seelig prefers the use of a gold chain to bismuth mush. He is not only able by its use to diagnose stricture, but diverticulum—if it is a complication—as well. One complication which has arisen is caking of bismuth mush; when this occurs there is a foreign body to deal with as well as the stricture.

By use of the bougie the stricture can be located, and its size as well as its toughness can be estimated.

Esophagoscopy.—By the use of the esophagoscope the stricture may be inspected as well as located. This is a very valuable means of diagnosis.

Treatment.—The time of treatment should be about four to eight weeks after a mechanical, thermal or chemical injury has been received. These conditions, however, may prevent such treatment. If for any reason operation is contraindicated rectal feeding should be resorted to.

Dilation of the stricture may be accomplished in various ways. When the strictures are large, esophageal bougies may be used. If there are a great number of strictures, this treatment may be very difficult, because when such conditions exist the upper strictures are dilated first, and the lower ones later.

When the strictures are almost impermeable, von Hacker's method, modified by Socin and von Mikulicz, may be used. It is as follows: The patient swallows a string upon which is placed several steel balls 3 to 4 cm. apart; the string is passed through the nose and fastened to the face.

Plummer (*Jour. Am. Med. Assn.*, pp. 560-563, Feb. 25, 1911) makes use of various instruments, not only to explore the esophagus but for treatment as well. He uses one which has a silk thread on the end which gradually increases in size until it forms a rigid staff. With such a device, the silk thread acting as a guid

it is possible to pass through a stricture and dilate it even though it is scarcely permeable. He also uses Mixter's method. The patient swallows six yards of silk thread; after the thread has passed into the intestines it is drawn tight by pulling on the end, which has been secured outside the mouth; then piano wire and other instruments are passed upon the thread as a guide. This is a very good way to dilate impermeable strictures.

The esophagoscope in the treatment of esophageal strictures has been very useful in the hands of Guisez (Traitement par l'esophagoscopie de nos de niers cas de retrecissements cicatriciels a forme grave de l'esophage. In *Archives Generales de Chirurgie*, Paris, Dec., 1909, ii, No. 12, pp. 554-664). He was able to cure 23 out of 28 cases. Through the esophagoscope he dilated or cut the strictures in this series. They were able to eat almost as well as other people. Long strictures with longitudinal infiltration were the most difficult to cure because they were also inclined to recur.

A bent glass tube covered with rubber is a useful instrument to pass filiform bougies into the stricture. In passing the bougies the tube is passed until it comes in contact with the stricture; the tube having been filled with bougies, they are passed into the esophagus.

W. Lerche. Cutting of strictures of the esophagus through the esophagoscope, *Northwestern Lancet*, Minneapolis, Feb. 1. By this method the filiform bougie could act as a guide for dilating or cutting instruments as in urethral surgery.

Gastrostomy.—When the patient has an impermeable stricture, and is too weak to undergo anesthesia, gastrostomy may be done. The patient is fed through a tube passed into the stomach.

Eastman of Indianapolis has advocated gastrostomy that the stricture may dilate because of non-use of the esophagus. It is true that there is spasmodic action of stricture when they are irritated by food; but it is doubtful if a dense stricture will yield to this treatment.

Strictures near the cardia may be best treated

through an opening in the stomach, especially when the strictures are of small caliber. *Methods, urethrotome,* small bougies, etc. Ochsner has passed a thread on a filiform bougie into the stomach and looped different sized rubber drainage tubes to the thread and pulled them into the stricture; when the tube is drawn taut it is of smaller caliber, but when the string is slackened the caliber of the rubber tube is increased, and thus the stricture is dilated. Tubes of different caliber may be passed into the esophagus in this way at various times. Perhaps if the string were swallowed before the operation it would be a great saver for the operation, as the tubes could be placed on the string without the introduction of the string by a filiform bougie.

Case 1: Child, male, 2 years 5 months; swallowed Red Seal lye on the morning of June 29, 1910. Shallenberger called and gave proper treatment. The doctor turned the patient over to me, as it occurred in one of my families. I saw the child in the afternoon. Its abdomen was distended and tender, which would indicate that the stomach at least was involved. During July I was out of the city, and Dr. Shallenberger was again in charge of the case.

A small tumor was present on the back of the tongue. It perhaps was due to infection, as it disappeared under antiseptic treatment. During the early part of August dysphagia developed, the child depressed its chin during deglutition. There was pain in the hepatic region during deglutition.

September 17, 1910, the child regurgitated food, but when I reached the home the spasmodic action of the esophagus had ceased, as it was able to swallow water. It complained of pain in the gastric region after swallowing water. Bronchitis was present, later the tonsil had a streptococcic and staphylococcic ulceration upon it. It was anemic and weak, and in no condition for any kind of an operation. At this time later conditions were more favorable. On October 12, 1910, Dr. B. M. Ricketts was able, only with great difficulty, to pass bougies through the upper strictures, but not through the cardia.

The child was able to take nourishment very nicely after regurgitating a quantity of mucus. The improvement was only for a few days, and the child again regurgitated its food with blood and mucus. At this time and before HCl was present in the regurgitated liquid, but pepsin was not present. Rectal feeding was resorted to at this time and before the first operation.

On October 18, 1910, at the Bethesda Hospital, I assisted Dr. B. M. Ricketts in an operation upon our little patient. Bougies would pass the upper strictures but not the one in the cardia. An incision was made over the left rectus, the stomach brought out and opened.

Upon examination it was found that only a small probe would go through this circular stricture. It was about one inch from the stomach. A small urethrotome was passed into the stricture and it was dilated. The operation was completed as a gastrostomy. The child was doing well at 9 p. m., and taking albumen water by the mouth. It was also given albumen water through the tube into the stomach. I was informed by the interne at 7:30 a. m., October 19, 1910, that the child was dying. It passed away at 1:45 p. m.

Non-cancerous stricture of the esophagus.—Sencert (*Arch. des Mal. de l'app. dig.*, March, 1911) describes strictures due to inflammation and cicatricial formation. The latter are much the more frequent, and are due to wounds of the esophagus by gunshot, or erosions of the mucous membrane by ulceration from diphtheria and the like, and the most frequent of all, boiling or caustic liquids. The inflammatory strictures may be due to syphilis or tubercle, etc. The diagnosis is based on the history, on inspection, palpation and auscultation of the thorax and neck. On auscultation of the esophagus the second bruit heard on swallowing is delayed from ten to twenty seconds after the first, instead of from six to eight as in health. A more important sign described by Reirdseff consists in the fact that if the patient after the second bruit is induced to make swallowing movements, but without

swallowing anything, a new bruit is produced three or four times, according to the amount of fluid originally swallowed.

Catheterization and radioscopy also give valuable indications, but esophagoscopy permits of a definite diagnosis being made. The prognosis is always serious; inflammatory strictures are less grave than cicatrizations. About one-third of all patients affected with stricture as a result of burns die if medical treatment has first been tried and found wanting. Treatment may be medical or surgical. Good results have been obtained from opium; mercury is sometimes of value in syphilitic strictures. Thiosinamin and fibrolysin have given good results in some cases, but should not be used for six months after the stricture has formed, and then only if there is no other disease present, such as tuberculosis, pulmonary or local. If after ten injections no amelioration is obtained, they should be discarded.

Thiosinamin is given in an alcoholic solution, 15 in 100, or thiosinamin 2, glycerine 4, aq. dest. 14.

Half a syringeful (Pravaz) to begin with, then a whole one twice a week. After the fifth injection it is advisable to wait for a few weeks. Fibrolysin is employed instrumuscularly, 3 c.cm. per diem. Surgical treatment consists in either making a new passage or acting directly on the stricture in one of the following ways: (1) Either from above by the mouth; (2) from below by opening the stomach, or (3) externally to the esophagus. (1-a) Cauterization not to be employed. (b) Dilatation by means of bougies, gradually increased in size, cylindrical or cylindro-conical, which are to be left in from five to thirty minutes, according to the sensitiveness or otherwise of the patient. In cicatrices from burns dilatation should not be commenced from six weeks to two months after the accident. Dilatation with the assistance of the esophagoscope is to be preferred to dilatation without it. (c) Electrolysis, linear or circular; the latter the author prefers, also with the assistance of the esophagoscope. (d) Internal esophagotomy, also with the esophagoscope. The author

believes in this method if the stricture is very short, above all if it is valvular, and also if it is short and very indurated, and undilatable. (*Brit. Med. J.*, Lond., July 15, 1911.)

TRANSTHORACIC.

Fisher (*Surgery, Gynecology and Obstetrics*, May, 1911) reports the case of a boy three years old, exhibiting a stricture incident to having swallowed lye. Instruments could not be passed. Therefore the abdomen was opened and an hour-glass stomach was found to have developed. A gastroplastic operation and a gastrostomy were performed, a rubber tube being pushed through the pylorus to the duodenum to put the sutured stomach at rest.

X-ray pictures taken later showed clearly a stricture, beginning at about the bifurcation of the trachea and ending one and one-half centimeters above the diaphragm. Bougies could not be passed, nor could a thread be flushed through, nor could an instrument be passed from below. Feeding through the gastrostomy wound did not seem to be successful. The child suffered from gastro-intestinal disturbances, with high temperature.

Under the insufflation of the lung the thorax was opened in the seventh intercostal space.

The ribs were separated and the lungs pushed away from the diaphragm. This incision was found to be too high. A second was therefore made in the eighth intercostal space, giving free access to the esophagus and the lower part of the diaphragm. The lung was pushed upward and held out of the way by Japanese silk handkerchiefs sterilized in vaseline. The pleura covering the esophagus was split, both vagi nerves were carefully isolated from the esophagus, and the latter was bluntly dissected out of its bed by means of forceps, this being easily accomplished without bleeding. By a gauze loop the esophagus was pulled well out into the wound. By carefully pulling the esophagus upward by this loop of gauze it was loosened all around its attachment to the diaphragm; a pair of anatomical forceps was pushed through the layer of the diaphragmatic pleura and peritoneum,

thus opening the peritoneal cavity. The stomach was carefully pulled into the thoracic cavity until a point was reached about 7 centimeters below the point of entrance of the esophagus. The pleural cavity was now carefully packed off with silk handkerchiefs and a transverse incision made between two silk sutures as guides in the cardia, 3 centimeters below the entrance of the esophagus.

Through this incision a ureteral catheter armed with a stylet and closed at the end was inserted. The stricture was easily entered from behind and the catheter led out through the mouth, where it was secured by a clamp. A long curved dressing forceps was inserted into the gastrostomy opening, and the lower end of the catheter was caught and pulled through this opening. The incision in the cardia was now closed by a double row of silk Lembert sutures, and the stomach replaced into the abdomen.

The esophagus was fastened to the diaphragmatic ring by interrupted silk sutures, care being taken to grasp enough peritoneum to produce a broad apposition of peritoneum to the esophageal wall. The incision in the intercostal spaces was closed by interrupted silk sutures, which were slung around the rib above and below the incision, care being taken to have the lungs fully expanded.

The child's death was attributed to the inspiration of some ether due to faulty management of the insufflation apparatus. (*Therap. Gazette*, Aug. 15, 1911.)

Esophagospasm may occur at any point in the esophagus from the cricoid cartilage to the gastro-esophageal junction. This condition was described as early as 1822, but while the literature is rather profuse with positive writings and case reports upon the subject, it has been one very seriously questioned by many; while it has been known as "cardio-spasm" there is no reason whatever why it should be so classified. Just as well apply the term pulmonospasm, diaphragmatic spasm, broncho-spasm, or what might be more appropriate, gastro-esophageal spasm.

Etiology remains mysterious, as varied in its changes as the seasons of the year. While many are assigned

definitely, others remain mysterious and undetermined, but now that the thoracic cavity and its contents may be examined with comparative ease and safety, the passing of the light of early morning into the light of mid-day may be realized. Of the many causes usually assigned, those of neurotic origin are prominent; that there is a definite pathology other than neurotic origin is beyond question. Changes in the pneumogastrics or the esophagus itself are no doubt responsible in the majority of instances for spasms. Hysterical spasm may be produced by worry, fright, joy, anger and grief. The exposure of a part or all of the body to cold air or water are frequent causes. A blow upon the chest has been assigned as the cause of degeneration of the vagi due to cicatrices; inflammation, adhesions and neoplasms may cause spasm or paralysis of the esophagus. Dividing the vagi will cause paralysis of the stomach and spasm of its cardiac portion. (Kirk.)

Esophageal pathology, minute or gross, will cause spasms. Esophagitis, fissure, ulcer, stricture, atony of the circular muscles, kinking of the esophagus at the hilus esophagi and neoplasms, and traumatism during instrumentation are supposed causes.

Irritants of any kind, due to any cause such as the presence of worms, solids, cold liquids, hemorrhoids, tobacco juice, gastric hyper-acidity, are also supposed causes.

Reflex causes seem to be numerous; among them are gastritis, endometritis, hepatitis and pregnancy.

Infectious diseases and toxemias, such as tetanus, pneumonia, scarlet fever and rabies, have been held responsible for spasm. It may be hereditary or acquired. One of two children, eight months old, reported by Beck, recovered from inherited spasms.

Symptoms may be sudden or gradual, constant or periodical, complete or incomplete, and vary in duration and time.

Dysphagia usually appears slowly, with more or less pain beneath the sternum or at the cricoid cartilage; food may be swallowed into the stomach, remain in the esophagus, or be rejected by the mouth, seldom if

ever doing so after it has entered the stomach. When regurgitated it is usually with mucus, sometimes after the meal. If the spasm continues for several days or weeks, inanition develops and death results in due time if surgical relief is not given. In mild acute cases food may be forced into the stomach with air by the patient's effort or mechanical means.

Diagnosis.—If a bougie meets with slight obstruction, and the patient experiences no trouble, the diagnosis is quite probable. Inability to pass a bougie does not necessarily indicate that spasm does not exist.

Mixter's method of swallowing six yards of thread and passing a bougie on the thread, may meet with success. By means of the bougie the depth of the spasm may be estimated and its position determined.

Schroder's method of diagnosis is to pass to the point of spasm a stomach tube, which, while held firmly in position, is filled with water; the end of the tube is then clamped with a pair of forceps and the bulb compressed, to force the water downward. Sometimes the spasm is overcome, permitting the water to enter the stomach, this establishing the diagnosis. (*Jour. Am. Med. Ass.*, p. 1790, May 30, 1908.)

X-rays are of great service in the diagnosis of the esophagus spasm, when bismuth-mush or foreign bodies have been introduced into the esophagus for the purpose of determining its location by skiagram.

Flesch and Peteri comment on the shocking frequency in children in Austro-Hungary of corrosion of the esophagus from drinking lye. At the Stefanie Hospital at Budapest there have been in the last nine years 516 cases of acute disturbances from this cause, and 267 cases of cicatricial stenosis of the esophagus, all the result of leaving a solution of lye ready to be used in washing within the reach of young children. It has proved possible to examine the condition with the Roentgen rays by having the children swallow a soft porridge containing 30 or 40 per cent. of oxid of zirconium. This substance is insoluble in acids, strong alkalies, etc., and seems to have no action when injected subcutaneously into animals, so that no toxic action need be feared from it. For Roentgen work it

has several advantages over bismuth. As the child swallows each mouthful of the porridge the progress of the mouthful down the gullet can be watched with the Roentgen rays, and the regions where it passes along smoothly and where it seems to be arrested or makes its way slowly are marked and compared. By this means it has proved possible to detect multiple strictures, and treatment applied on the knowledge thus obtained has proved remarkably successful instead of the blind, haphazard work without radioscopy. The details of twenty cases are given to show the workings of the method. Investigation in this way can be applied during the first six weeks after the injury when it is still dangerous to introduce a sound. (*Jour. A. M. A.*, Aug. 5, 1911.)

Prognosis should be guarded, because it may not interfere with the patient's nutrition. Some patients however have succumbed as the result of starvation.

Treatment resolves itself into medical and surgical, depending upon whether the spasm is continuous or periodical.

The medical treatment consists in giving the esophagus rest, feeding pre-digested food per rectum, and anti-spasmodics and tonics.

Surgical treatment is palliative and radical.

Palliative consists in dilation of the esophagus with sounds, some cases having been cured by passing them but a few times. Usually this is all that is necessary in the milder cases.

Radical treatment—gastrostomy—is one of the milder operations. It permits the food to be introduced into the stomach, thereby giving the esophagus rest until the constriction becomes dilated. It is not always a curative measure. Dilation of the esophagus through the stomach may be beneficial.

Trans-thoraco-esophagotomy is the most radical operation for this purpose. It involves plastic operations, tearing loose of nerves and the breaking up of lung and esophageal adhesions with esophagoplications.

Since the writing of this chapter, Dr. Dudley W. Palmer, in a most excellent paper discusses at length

seven of the most common etiological factors, three stages of its progress, diagnosis and prognosis.

ETIOLOGY.

1. Congenital predisposition.
2. Reflex.
3. Primary atony.
4. Atony of musculature due to degeneration of vagus nerves.
5. Primary esophagitis.
6. Kinking or angulation.
7. Primary spasm with secondary dilatation, which he considers the most important.

These, together with the bibliography and tables of frequency and age of occurrence, are generously supplied by the author for this work .

Frequency.—First decade of life showed 4 cases; the second, 5 cases; third, 15 cases; fourth, 26 cases; fifth, 20 cases; sixth, 6 cases; seventh, 4 cases; not stated, 9 cases. Total, 89 cases.

Youngest case, 6 months; oldest case, 65 years; average age, 35.2 years; males, 55 per cent.; females, 45 per cent.; length of shortest history, 6 weeks; length of longest history, 27 years; average length of all histories, 6.2 years; average length of all histories without symptoms of dilation, 2.55 years. 17 per cent. cases seen before dilatation symptoms developed; 83 per cent. cases seen after dilatation symptoms developed. Onset sudden in 20 per cent. cases. Onset comparatively gradual or mild and intermittent in 80 per cent. cases.

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DILATATION.

Technique.—Dilatation of stricture with bougies varying in size, length and flexibility, has been extensively employed for many years. They have been introduced through the mouth, incisions in the neck, and through the gastro-esophageal opening. Introduction of bougies through the mouth may be accomplished with or without anesthesia with loss of consciousness, and with or without local anesthesia, especially if there is but little difficulty.

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FOREIGN BODIES.

Foreign bodies, when impossible to remove them through the mouth, removal may be done through the neck or thorax. After suturing the incised walls with catgut, drainage should be provided, because all such wounds are subject to infection from the contents of the tube.

After having passed the cricoid cartilage they usually lodge in the second constriction corresponding with aorta and left bronchus. The third constriction (cardiac) is where the esophagus passes through the diaphragm, but foreign bodies are less inclined to become lodged in it. However, they may become impacted at any point within the canal from the diaphragm to the cricoid cartilage.

Foreign bodies with round, smooth surfaces are less

likely to be impacted than those with rough, uneven surfaces.

When in the first and second constriction they can be removed through an incision in the neck.

Some of the great dangers from foreign bodies are obstruction, ulcerations, perforations and subsequent cicatricial contraction. Some foreign bodies may be perforated to such a degree as to permit the passage of liquid food, when no serious trouble may ensue for a considerable time. However, pressure upon the bronchus or trachea may cause suffocation.

The dangers of ulceration are perforation with infection and hemorrhage which may or may not become fatal. The vessels involved in such an accident are the carotids and lower aorta in the order of their occurrence. The pericardium being in front of the esophagus, has been occasionally perforated, as has also the pleura on the left side, above on the right side and below and indirectly the lungs.

Various articles, as food, coins, nails, false teeth, fruit stones, splinters, bones, jack-stones, safety-pins and other varieties of things find their way into the esophagus. They may be hard, soft, smooth, rough, sharp, round, or they may have projections. The patient may introduce them through the mouth by accident, for the purpose of suicide, or they may be introduced by some one else. During anesthesia, or a drinking bout, the foreign body may be regurgitated from the stomach. How soon a foreign body will do damage, after it has lodged in the esophagus, will depend upon the kind of a foreign body. One with sharp edges will wound the esophagus at the time of its introduction. While a coin, as in G. Guiez's case (*Archives des Maladies de l'App. Digestif,* Paris, Apr. 4, No. 4, pp. 177-240), may remain for four years without apparent damage. If the body is impacted, or if it has penetrated the wall, gangrene in the former and sloughing and fistula in the latter may occur. When fistula occurs, the foreign body may remain in the esophagus, or pass out into the fistula. The condition is more serious if a diverticulum, stricture, ulcer or neoplasm is the resting-place of the foreign body.

Symptoms.—Pain is usually the first symptom complained of after a foreign body has been engaged in the esophagus, and if it passes to a lower level, pain marks its passage. The point at which the body has lodged does not necessarily correspond to the point of pain, neither does the point indicated by the patient as the point of lodgement necessarily correspond to it, nor does it indicate whether or not it has passed into the stomach. Inability to swallow liquids or solids is of significance when obstruction occurs where no previous trouble has before existed.

Diagnosis.—If during mastication, sleep, anesthesia or acute alcoholism, in a person who has not presented signs of mediastinal tumor, or has not had previous traumatism, or where there is not a probability of ulcer, there is a sudden obstruction with pain, the probability of foreign body or esophagospasm is apparent.

Bougies may be used when the foreign body is known to be soft or smooth and when the occlusion is complete, otherwise the bougie may pass the obstruction without any indication that a foreign body is present.

Esophagoscopy is the most positive means of diagnosis. It has the advantage of being able to remove the foreign body at the time of the examination.

Anesthesia is advantageous during these examinations. The use of X-ray is limited to such articles as metal, rubber, wood and bone, as these are seen through the fluoroscope or will produce a radiograph.

Treatment is surgical or non-surgical.—Non-surgical: The nature of non-surgical treatment to be employed depends upon the kind of foreign body present, whether rough, sharp, smooth, soft, or of digestible material. Warm liquids are given to swallow, with the hope that they may dislodge the foreign substance. An emetic may be given in the form of apomorphine, if no contraindications exist. If the foreign body is digestible, pepsin, dilute hydrochloric acid, papain or taka-diatase may be given separately or in combinations. If the article is not digestible, dilute hydrochloric acid or strong cognac may be given to shrink it.

Surgical treatment.—The treatment employed should depend upon the location or kinds of foreign bodies. Those which are smooth, rough or sharp, when located at the entrance, or just within the esophagus, may be removed through the mouth with forceps; while those located below this point, if the substance is a coin, causing partial obstruction, or some smooth or soft substance of reasonable size, may be removed with a coin catcher or bougie respectively. When bougies are not at hand, a soft stomach tube with an opening at the end and a bulb in the middle, may be used in place of the bougie. Should the foreign body not yield to reasonable pressure, a hemostat clamped at or near the funnel, the stomach tube having been filled with water and held tightly against the foreign body, while an assistant holds the clamped end of the tube or operator presses the bulb, thus causing more pressure to be exerted at the point most needed. (Schroeder has advocated this as a differential diagnosis between stricture and esophagospasm.) If the above means fail, then the esophagoscope may be used.

Before the introduction of the esophagoscope and hypodermic administration of atropine or hyoscine should be used to dry up the esophagus and prevent the formation of mucus during the operation. The rule used is to remove, when possible, all foreign bodies above the bifurcation through the mouth, those below the bifurcation through the stomach. Various instruments may be used for this purpose, as hooks, forceps and bougies. If the foreign body is small, the esophagoscope may pass over it. Because of this the fluoroscope is of advantage when the bodies can be seen through it.

When there is an impaction, or if the body is such that an intra-esophageal extraction is too hazardous, then the operator will reach the foreign body through an incision in the neck, thorax, or stomach, depending upon its location.

"In all cases in which a foreign body is either swallowed or inspired, Bowen says a radiograph should be made by a competent person before any attempt is made at its removal. This is especially important in

cases of sharp bodies. If the foreign body is dense enough to be revealed on a plate, the diagnosis by this means is easy, but even in those cases in which a vegetable foreign substance is not opaque to the Roentgen-ray, a great deal of information can still be obtained. A grain of corn, for instance, lodged in the bronchus, will not cast a shadow on a photographic plate, but its presence can usually be determined by the slight changes in the lung itself, caused by a localized pneumonia or by a blocking up of certain air cells. The same is true of vegetable foreign bodies in the esophagus, for while the body itself can not be seen, information especially as to its location can be obtained by giving the patient bismuth, either in the form of a capsule or in gruel, and watching the passage of the preparation down the esophagus with the fluoroscope. If a foreign body is present, the bismuth will be stopped or at least hesitate at the obstruction. The method to be employed in the removal of foreign bodies after their nature, size and position has been determined, must be carefully considered, and Bowen believes that the outcome of the case depends more on the proper selection of the method to be used than on the instruments used or the operator selected. He has had thirteen cases, in all of which the foreign body was removed without difficulty, and most of the cases required not more than two or three minutes for the actual removal of the foreign body. The one method which Bowen has used more than any other and the one that appeals to him most, is the removal of foreign bodies with an ordinary pair of forceps, passed into the esophagus or into the bronchus through a tracheotomy wound, while the parts are being examined with a fluoroscopic screen. Bowen has removed tin whistles, coins, open safety-pins, tacks, needles, pins, etc., successfully."

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NEOPLASMS

Neoplasms, malignant or non-malignant, sometimes require removal by one of the several methods em-

ployed for that purpose in the upper or lower third. Possibly only non-malignant growths should be excised, and only one inch of the length of the tube should be removed, because the esophagus is not elastic and will not permit of anastomosis, and such cases require watchful care and drainage.

Non-malignant neoplasms are cystic, polypoid, tumored and ringed.

The cystic are of two kinds, the glandular retention cysts and the ciliated epithelial cysts. The glandular retention cysts do not become larger than a cherry, and cause no symptoms, while the ciliated epithelial cysts, located at the bifurcation, become larger and cause dysphagia.

Polypoid neoplasms are fibromas. Their attachment is above the cricoid cartilage, at the cricoid cartilage on the anterior wall, or at some point below it or above the bifurcation, and the pedicle may be long or short. Cases are recorded which had a long pedicle, with their attachment near or at the cricoid cartilage, where the patients regurgitated them into the mouth, seized them between their teeth and bit them off. If the attachment is above the esophagus the polypoid may hang down into it.

Tumored.—They are fibroma, lipoma, papilloma and myoma. Myomas are sometimes mixed, then they are leiomyomata, rhabdomyomata and myo-fibro-lipoma. The two latter are usually malignant. It only seems reasonable to suppose that any of the other forms may become malignant at times.

Malignant neoplasms.—There are three kinds of malignant neoplasms of the esophagus—carcinoma, sarcoma and lymphosarcoma. Schlagenhuffer reported one case of lympho-sarcoma, and this is possibly the only one on record.

Carcinoma is much more frequent than any other malignant disease of the esophagus.

Etiology.—Although great effort has been made to find one, no accepted cause has yet been discovered. However, there are predisposing causes which produce soils in which cancers flourish. Such soils are the ulcered, cicatrized and catarrhal, and they are pro-

duced by chemical, thermal and mechanical agents, as well as disease. Thermal agents and caustics produce the ulcer and its stricture, while tobacco and alcohol produce a catarrhal soil. Perhaps the two latter agents cause carcinoma to predominate in the male. Mechanical callings, as sword, spear or bayonet-swallowing, or the lodgement of a foreign body, cause a catarrhal, if not a traumatic, condition. The ulcer of syphilis or tuberculosis, diverticulum, traction diverticulum and esophagospasm are soils in which carcinoma develops.

Usually carcinoma arises from one point of origin in the pavement epithelium; however, W. G. Seelig, of St. Louis, reported a case with two primary carcinomas of the esophagus with autopsy. Cauliflower and papillomatous carcinomas are frequent, while glandular and colloid types are rare. The neoplasm may be hard, soft, fibrous or ulcerated. All parts of the esophagus have been given by authors as being the most frequent point of origin. The lower third, however, where the left bronchus passes over the esophagus, is probably the most frequent point of origin. The ring formation is the one which is most frequent, and the width of the ring may vary from three to ten centimeters. (Strumpel, 413.) Or, on the other hand, all of the esophagus may be practically involved, as when a ring formation is present, then the esophagus is dilated above this point.

Strumpel (page 413) has frequently seen cases of the flat variety, with no clinical symptoms and no diagnosis, where gangrene of the lung or extensive secondary hepatic lesions were found.

The neoplasms may spread from the esophagus to surrounding organs by continuity, and *vice versa.*

Metastases may take place in the lungs, liver, brain, bones, spleen and kidneys.

Erosions may occur into the pleura, lung, bronchus, trachea, pericardium, endocardium, spinal cord, the pulmonary vessels or aorta. When the erosions take place into the spinal cord paralysis results. Gangrene of the lung may result from regurgitati

Symptoms.—L. Lemy in a series o ound

the following facts regarding the symptoms of carcinoma of the esophagus: Pain present in 58.6 per cent.; progressive difficulty in swallowing as the first sign, 75.3 per cent.; good appetite in 70 per cent.; regurgitation in 83 per cent.; sudden inability to swallow in 6.7 per cent.; pain and dysphagia developing at same time, 10.5 per cent.; pain before dysphagia, 4.8 per cent.—*Archives des Maladies de l'App. Digest,* Paris.

Diagnosis.—A patient above 40 years, with dysphagia, with or without cachexia, constitute symptoms enough to warrant an examination with the esophagoscope and X-rays. If more early diagnoses are made better surgical results may obtain. If the supra- or infra-clavicular glands are much enlarged and indurated, the diagnosis of a carcinoma of the esophagus mediastinum is very probable. In the mediastinal cases there will be, in time, a bending forward and orthopnea, the thorax may be raised and a compensatory circulation may be present. When the superior infra-clavicular glands are enlarged, the time for surgical interference, except as a palliative measure, has passed. The improvement of dysphagia should not change the diagnosis, as ulceration of the esophageal carcinoma is frequently accompanied by a temporary improvement in dysphagia.

When the X-rays are used the esophagus is filled with bismuth-mush and a skiagram is obtained. There is one danger of the bismuth-mush not escaping and acting as a foreign body. Such cases are reported in the literature. By the carcinoma-skiagram the location and probable complications are estimated. Thus the advisability of operative interference is better considered. Carcinoma of the cervical portion of the esophagus may be palpated when the neoplasm has reached sufficient size. Paralysis of the vocal cords in carcinoma of the esophagus or in tumors of the mediastinum is due to pressure on the recurrent laryngeal nerve and is enough to demand a rigid investigation to see if the above conditions are present. The microscopic examination of regurgitated material may be sufficient to make a diagnosis.

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ESOPHAGECTOMY.

Professor Kuttner (*Beitr. z. Klin. Chir.*). Resection of the thoracic portion of the esophagus for cancer was attempted in four cases, with fatal result in each. To obtain any success in this most dangerous procedure, the exact location of the growth must be determined by an excision of parts of the tumor with the aid of the esophagoscope. Radical operation is best adapted for intrathoracic esophageal cancers in the vicinity of the diaphragm, but before resorting to it, it is important to previously open the abdomen through a small incision to determine whether the growth has extended into the abdominal cavity, and also whether it has involved the lymphatics about the lesser curvature and the retroperitoneal tissues. If an examination fails to disclose any or slight involvement, there is then reason to believe that the conditions in the thorax are favorable for its extirpation. There is also hope of operative success in malignant tumors of the cervical portion of the esophagus extending into the thorax.

Sedillot (1847) re-established the esophageal canal, obstructed by stricture, by circular resection and suture. Since then, partial and complete resections have

been done more or less frequently for various kinds of neoplasms, especially carcinomata in the various portions of the tube, with a considerable degree of success in restoring function, making comfortable and prolonging life.

That portion occupying the cervical region has been the first and most frequently attacked.

"Complete" applies to the resection of the neoplasm only, not the esophagus in its entirety, though such procedure is now possible; but nutrition must be by the introduction of food directly into the stomach by gastrostomy.

Sometimes it becomes necessary to remove a portion of the esophagus, with or without anastomosis. This is done with greater facility in its upper and lower third, but what may be expected to be done with the middle third there is much doubt.

Indications for esophagotomy.—Stricture and neoplasm.

Stricture.—Sometimes it is necessary to remove a portion of the esophagus, when it is occluded by a new growth in the upper or lower third. The inelastic nature of this tube precludes the possibility of removing more than one inch of its length with any hope whatever of re-establishing its function by anastomosis.

Neoplasms in the upper or lower third, with or without stricture, sometimes necessitate removal alone, or by excision of a portion of the esophagus.

Neoplasms, when not too extensive, and causing occlusion in the lower portion of the esophagus, may be removed and the proximal ends anastomosed to the stomach by pulling the stomach through an incision in the diaphragm; the distal end is inverted and closed by suture. Drainage should always be provided for, tape being the material of choice.

Torek (*Journal of Surgery, Gynecology and Obstetrics*, page 614, June, 1913) reports the first successful case of resection of the thoracic portion of the esophagus for carcinoma:

"In a case operated at the German Hospital, on

March 14, 1913, I succeeded in demonstrating the feasibility of resection of the middle portion of the esophagus for carcinoma. The patient, a woman of sixty-seven years of age, had a carcinoma of the esophagus, beginning just below the border of the transverse portion of the arch of the aorta and extending from there downward for about one and three-quarter inches. A pair of very beautiful stereoscopic X-ray pictures, taken by Dr. William H. Stewart, demonstrated the condition before the operation. I had performed a gastrostomy upon her some time previous to the resection of the esophagus. Knowing the difficulties of the case, the problem was to plan the ways and means of overcoming them.

"The method of access to the field of operation was as follows: Instead of going through two different intercostal spaces and dissecting off the scapula, or of resecting several adjacent ribs, as recommended by others, the incision was carried through the whole length of the seventh intercostal space, from the posterior end of which it was extended upward by cutting through the seventh, sixth, fifth and fourth ribs near their tubercles, which gave a much better exposure and is far simpler.

"Extensive adhesions between the lung and the parietal pleura were present, the greater part of the lower lobe being attached both to the costal and the diaphragmatic pleura. The firmest adhesions were at the apex. All these were separated. The tumor was found to be fairly fixed in the position above described, viz.: just below the lower border of the transverse portion of the arch of the aorta, allowing only very slight mobility. The portion of the esophagus below the tumor, between it and the diaphragm, was exposed in the usual manner by incising the pleura, drawing the vagi aside, and lifting the esophagus out of its bed. At the site of the tumor the dissection of the vagi was more difficult, and some of the branches crossing over in front of it had to be cut in order to permit liberating the tumor without undue roughness in handling the vagi. To my great satisfaction the pulse never wavered during this procedure, remaining

between 93 and 96. The dreaded vagus collapse had, therefore, been safely avoided.

"The dissection of that part of the esophagus which passes behind the arch of the aorta offered great difficulties, which were finally overcome by dislodging the aorta at that site and lifting it forward, after having ligated and divided a number of its thoracic branches. Getting the aorta out of the way, where it crosses the esophagus, is of considerable help in liberating the latter; in simple cases, however, I feel certain that the dissection could be done without ligating the thoracic branches of the aorta. The tumor was attached to the left bronchus, which sustained a longitudinal cut during the progress of the separation of the tumor from it. The cut in the bronchus was afterward sutured with silk.

"The esophagus had now been detached from its bed, beginning at a point about an inch above the diaphragm, up to about an inch above the arch of the aorta. The resection of the carcinoma, *in situ*, could, therefore, have been easily performed. But my plan was different. I had come to the conclusion that the rational way to deal with the danger of leakage from the upper stump of the esophagus was to eliminate that organ from the pleural cavity altogether. I, therefore, dissected the esophagus loose from its attachments all the way up to the neck, divided it with a cautery at a safe distance below the carcinoma, after double ligation, and brought the esophagus with the tumor out through an inclsion in the neck at the anterior border of the left sterno-cleido-mastoid muscle. Thus the pleural cavity could not possibly become infected from that source. The ligation of the lower stump had been made after first crushing the esophagus at that site. This stump was invaginated like an appendix stump, only with the difference that two successive pursestring sutures of silk were used instead of only one, as in the case of the appendix.

"The thorax was now closed, silk threads being used to hold the seventh and eighth ribs together, chromicised catgut for the muscles and silkworm gut for the skin. No drainage was employed. Now the esopha-

gus, which was hanging out from the wound in the neck, was placed under the skin of the chest. For this purpose a transverse incision was made in the skin at a place corresponding to what was going to be the free end of the esophagus after the carcinoma was cut off, for at the time this was still attached. The site of that incision in this case corresponds to the second intercostal space. The skin between the incision in the neck and the new incision was tunneled, the esophagus drawn through, the carcinoma cut off, and the fresh rim of the esophagus sutured to the skin. The neck wound was closed.

"As regards other details of the operation, I may say that the incision through the skin and muscles was made under local anesthesia, one-half per cent. novocain with suprarenin being used. The general anesthesia was given by tracheal insufflation according to deltzer-Auer, the apparatus constructed by Dr. Hermann Fischer being used. It worked very satisfactorily. The employment of a differential pressure chamber, either positive or negative, could not be considered, as the rubber cuff around the patient's neck used in such an apparatus to separate the air about the head from the air about the body would have interfered with the operation at the neck.

"From the notes taken by Dr. Carl Eggers, who administered the anesthetic, I extract the following: For the induction of anesthesia, 15 c.c. of anesthol was used. Then intubation was performed, a woven silk catheter, No. 18 French, being introduced with the aid of the finger. The catheter was fastened to the upper lip by suture, as the patient had no teeth to which to tie it. Ether was used now for anesthesia, 100 c.c. sufficing for the entire operation. The pulse was regular and of good quality throughout the operation, except when the aorta was strongly pulled over for the purpose of suturing the cut bronchus. At that time it became weak and rose to 102. Strychnine, caffeine and camphor were used for stimulation. A hot coffee enema with whisky and strychnine was also given at the end of the operation. The intrathoracic portion of the operation, from the incision of the

pleura to the closure of the thoracic cavity, took one hour and forty-five minutes; the whole operation, from the first incision to complete closure, two hours and forty-three minutes; the general anesthesia, two hours and twenty-seven minutes.

"The micoscopic examination of the specimen made by Dr. Frederick B. Humphreys proved the new growth to be a squamous celled epithelioma. From his description I quote the following: In the center of the specimen there will be found a ragged indurated ulcer, roughly circular in form, measuring 4.6 cm. across and 4.3 cm. from above down. The ulcer extends over the entire circumference of the mucosa, excepting a small strip about 0.8 cm. in width. The floor of this ulcer is ragged, reddened and firm, the edges raised and nodular and fairly well circumscribed. The adjacent portions of the esophageal mucosa show a few small, non-ulcerated, raised nodules, but at the lines of section the mucosa appears entirely free from invasion. The outer surface is rough. The external coat is slightly lacerated, but nowhere has the tumor microscopically grown through excepting in one region where there is a nodule about 1 cm. in diameter. Immediately over this nodule is a soft anthracotic-lymph node attached to the muscle.

"My assistants at the operation were Drs. Frederick H. Dieterich, Martin Bry and Albert Barge, members of the house staff of the German Hospital. The patient made a good recovery.

"The stitches were removed, some on the fourth day and the remaining ones on the seventh day, when the wound proved to be completely closed. The pulse, respiration and temperature had become normal by the fifth day. The highest point that the temperature had reached was 102 F., on the third day after the operation.

"Up to the eighth day after the operation the patient was nourished in the same manner as before the operation, through the gastrostomy tube with a funnel attached. After that time the free end of a gastrostomy tube was introduced into the cut end of the esophagus for the purpose of feeding the patient.

"The rubber tube being of somewhat smaller caliber than the esophagus, the patient has to make slight pressure upon the skin to one side of the tube to prevent leakage. This is accomplished by the patient without the slightest trouble, and she now swallows all varieties of food that can be chewed into an almost fluid state, such as bread, cereals, potatoes, eggs, spinach, etc. As she had not been able to take any bread for about nine months before her operation, she feels very happy with her rubber esophagus.

"A number of methods of esophagoplasty have been devised, the most promising of which at the present time seems to be that of Jianu, utilizing the greater curvature of the stomach to form an esophagus. This is placed under the skin of the thorax and in favorable cases may reach up to the end of the divided esophagus so as to render a union of the two ends possible.

"Now that the way for a successful performance of this operation has been shown, it is our evident duty to advise operation as soon as the presence of a carcinoma of the esophagus is recognized, remembering that success depends to a great degree upon early diagnosis, and early operation, and that it is not wise to wait until the difficulty in swallowing becomes marked before our suspicion of the presence of cancer is aroused."

ESOPHAGECTOMY.

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ESOPHAGORRHAPHY.

Suturing the esophagus is a practical method for correcting the conditions indicated. It may be done through the neck or thoracic cavity, the upper or lower third being most available. Now that intratracheal insufflation and the vacuum chamber have been proven to be of so much value, much more may be expected in surgery of this tube. The responsibilities of the after-care are great, because of leakage with its consequent infection, with or without operative measures. The after-care pertains to judicious feeding, probably by the rectum, for several days.

Indications for esophagorrhaphy.—Incision, laceration, puncture, rupture, and fistula.

Incisions, accidental or induced, vary in number, length, direction and location. They may be complicated with wounds of other organs or tissues.

Lacerations may be acquired or induced, circular or oblique, partial or complete, regular or irregular, single or multiple, in any location, and associated with other ogans or tissues.

Punctures, accidental or induced, may vary in size, shape, number, location, from within or without, and associated with wounds of other organs or tissues.

Ruptures may be from within or without (usually from within), and vary in size, number, location and direction.

History.—Boerhave reported a case of rupture of the esophagus in 1724. His patient, Baron Wasseeman, died, as have all the other recorded cases up to this time. In 1877 Fitz reported a case and analyzed

the literature. About twenty cases have been reported up to this time.

Etiology.—Rupture of the esophagus may follow an injury, or it may occur if ulceration is present. If the esophageal tissue has been altered and destroyed by caustics, rupture may occur.

Malacia of the esophagus, because of hyperacidity of the gastric juice which is supposed to be the usual cause. When an esophagus has undergone such changes as mentioned, rupture follows vomiting. The vomiting is prolonged and may follow a large meal, anesthesia or alcoholism. Rupture may also occur during lavage. Thus far, most of the cases have been in alcoholics.

Geo. Gottenstein is of the opinion that rupture does not occur unless the inferior constrictors of the pharynx are closed.—Keen's Surgery, vol. iii, page 792.

The rent is usually in the lower half, and is usually longitudinal. One case is reported where the rent is transverse (Gottenstein, Keen's Surgery, vol. iii, page 792). What is to prevent the rents taking place at any angle?

Symptoms.—Nausea and vomiting are the first symptoms manifested. Sudden pain is experienced in the chest and epigastrium. Vomiting ceases. Emphysema of the neck and chest may occur. The patient soon passes into collapse, and detath usually occurs within twenty-four hours.

Prognosis.—Thus far all cases have been fatal.

Treatment.—By using intratracheal insufflation or Sauerbruch's box, early operation may save some of the cases.

Dr. I. J. Walker, Boston (*J. A. M. A.,* vol. lxii, No. 25, pp. 1952-54, June 20, 1914), reports twenty-two cases of spontaneous rupture of the esophagus from 1724 to 1914, twenty males, two females, all occurring suddenly. Duration of life, from 4 to 180 hours. Four were due to debauch, and nearly all of the twenty-two ruptures occurred just above the diaphragm, and all resulted in death. He concludes by saying that:

1. Spontaneous rupture of the apparently healthy esophagus is a rare condition.
2. The exact cause is not known.
3. Accurate diagnosis is difficult.
4. The mortality will always be high.
5. The average duration of life was 30.4 hours.

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FISTULA.

Etiology.—Fistula of the esophagus may be congenital or acquired. Foreign bodies, suppuration of

the lung, of tracheo-bronchial glands, mediastinal abscess and injuries to the esophgaus are common. These fistulous openings may communicate with various thoracic viscera, and may or may not communicate with the outside of the chest. A. H. Meisenbach in a personal communication reports a case of esophageal fistula making exit in the left seventh intercostal space about two inches to the left of the nipple; he made a diagnosis by having the patient swallow methylene blue and observing its escape at the point of the fistulous exit.

E. Pachnio (*Archiv. fur Verdaungskrankheiten,* Berlin, Aug. 12, 1908, xiv, No. 4, pp. 369-478) reports a case where a healed tubercular lung caused a diverticulum by its contraction. The lung-lesion became active, and this caused a fistula into the diverticulum.

A. R. Robertson of Boston reports a case in *Boston Med. and Surg. Jour.,* August 12, 1909, where the esophagus consisted of two distinct portions, separate from one another. The upper portion opened above the tracheal bifurcation, while the lower portion opened into the stomach at its lower portion, the upper part forming a fistulous communication with the posterior wall of the trachea 8.4 mm. above the bifurcation and 6 mm. below the cul-de-sac of the upper.

A. Staehelin Burchardt reported a case (Aug. 16, No. 4, pp. 419-536, *Archiv. fur Verdaungskrankheiten*) of tuberculous fistula of the esophagus, with no chronic lung involvement and no tuberculous sputum, with tuberculous meningitis and tuberculous fistula of the esophagus.

Etiology.—Perforation from within, without tuberculosis in diseases of the esophagus. (Gardiere in *Gazette des Hopitaux,* Feb. 5, 1910.)

Diagnosis.—Gerhardt's method. Pass one end of a tube into esophagus and place the other end of the tube in water. If there is a fistula, bubbles will appear in the water during inspiration. When the fistulous opening has an external exit, use methylene-blue as did A. H. Meisenbach.

Erosions of carcinoma into various organs leave a fistulous path.

Fistula opening between esophagus and trachea on dogs. (*Deutsche Zeitschr. f. Chir.*, Leipz., Apr., 1905.) Experiments on dogs. Ligated arteries in thyroid, detached, found and made it movable and used the gland to cover defects in esophagus.

Technique.—After exposing the esophagus by thoracotomy, continuous or interrupted sutures of silk or linen are applied in the usual way. All wounds of this tube are more or less infected; being so precludes the possibility of using catgut for suture. Fine needles, with silk or linen suture corresponding in size, are preferable, and when possible should supplant all others. Drainage should always be considered, because of infection of this tissue.

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ESOPHAGOGASTROTOMY.

Esophagogastrotomy is done through the thoracic wall, with a positive differential pressure-chamber

(Meyer). It is one of the greatest and most recent accomplishments in surgery. It may also be done with intratracheal insufflation.

Indications for esophagogastrotomy.—Neoplasms, when not too extensive, and causing occlusion in the lower portion of the esophagus, may be removed, and the proximal ends anastomosed to the stomach by pulling the stomach through an incision in the diaphragm, the distal end being inverted and closed by suture. Drainage should always be provided for, tape probably being the material of choice.

PHARYNGOTOMY.

Technique.—It is especially desirable when a stricture is high, inelastic and very small, to open the esophagus below such obstruction through the neck, especially when other strictures are present lower down, and for the purpose of introducing food into the stomach when other strictures do not exist. Such an incision will also permit of the upper stricture being divided and properly cared for. A tube may then be introduced through the mouth and into the stomach, and the severed wall of the pharynx sutured and closed with provisional drainage. The tube through which food has been introduced into the stomach may be withdrawn at the end of the fifth, sixth or seventh day. Bougies varying in size may be systematically introduced after the expiration of twelve days, dating from the time of operation.

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TRACHEOTOMY.

Technique.—It sometimes becomes necessary when esophageal neoplasms are large and press upon the trachea, to make a tracheotomy that suffocation may

be prevented. It is advisable in such cases to open the trachea as low as possible that respiration may be better assured when a tube is left in the trachea. Such an operation may be readily performed with or without local anesthesia.

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GASTROTOMY.

Technique.—It becomes necessary, when obstruction of the esophagus is complete, to make a gastrotomy for temporary or permanent feeding; usually the abdominal wall is incised one inch to the left of the median line, the stomach opened and immediately closed or sutured into the abdominal wall by one of the various methods. Without the presence of malignancy, such an opening may be maintained indefinitely, thus permitting the necessary amount of food to be introduced and digested.

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Technique.—After opening the stomach through an incision in the abdominal wall, sounds may be intro-

duced into the esophagus many times with excellent results. Urethral dilators may also be used for this purpose, including the cutting instruments.

Corner urges that the methods of gastrostomy described and based on the principles of Depage's operation offer a means of doing a gastrostomy with good results comparatively early in the course of esophageal obstruction, while the patient is in good condition. By such means it will be possible to diminish the mortality and improve the results of the operation of gastrostomy in a marked manner. Corner has applied the principle of Depage's method to the formation of a cecostomy where for some reason or other the operation of appendicostomy could not be done or was a failure.

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The after-treatment for operations upon the esophagus pertains to all alike, drainage being necessary. It is best accomplished with tape or rubber tube, which

should remain in place until secretions cease or repair is complete, irrigation being seldom necessary. The diet should be albumen-water and broths for three or four days, with an additional soft-boiled egg after this time. Recumbency should be continuous from the first to the tenth day, at which time the semi-erect position may be assumed for several days, or until able to leave the bed.

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CHAPTER XIV.

THYMUS GLAND.*

SURGERY OF THE THYMUS GLAND.

1. Intubation.
2. Tracheotomy.
3. Thymotomy.
4. Thymopexy.
5. Thymorrhaphy.
6. Thymectomy.

Thymus gland.—There is perhaps no earlier, certainly no work more complete, on the anatomy of this gland than that presented by Sir Astley Cooper (1832). His dissections and injections of the fetal and adult glands of both animal and man, with mercury, wax and alcohol, have not been surpassed in excellence except as to its minute anatomy, an art which was not known at that time. It is, therefore, necessary to quote freely from his work. He recognized the importance of the gland during fetal and infantile life, and he also recognized the difficulties encountered in considering it as a surgical possibility, because of its small size, delicate texture and soft, pulpy nature, in the human infant. He selected the gland of the calf in preference, that he might learn the structure by which the fluid is secreted; the cavities containing it; the vessels by which the fluid is carried away, and to collect it in sufficient quantity to make it the subject of chemical analysis.

Anatomy.—There are no distinct capsules surrounding the thymus gland.

Surgical Anatomy.—The thymus gland is formed of a thoracic and a cervical portion on each side. The

*An illustrated lecture delivered to the students of The American Medical College, St. Louis, Mo., April 19, 1911.

former is situated in the anterior mediastinum, and the latter in the neck just above the first bone of the sternum and behind the sterno-hyoidei and sterno-thyroidei muscles. At the end of the tenth week of fetal life the gland becomes perceptible, and by the end of the seventh month it enlarges out of proportion to its former growth. At the end of the ninth month it suddenly becomes greater in size, weighing about one-half ounce, and continues to increase in size for one year. It is neither perceptibly increased or diminished (Hewson), but after this time it slowly disappears until puberty, and in after life it ceases to have cavities and becomes a body of very small dimensions (Cooper).

Hewson states, however, that it decreases in size from the third to the tenth year, and that it is ordinarily completely obliterated by the end of the twelfth year, leaving only ligamentous remnants that degenerate into a kind of reticular substance. He also states that he has never seen an instance of the thymus continuing to the time of puberty; but I have observed vestiges of this gland in a male cadaver thirty years old (B. M. R).

Occasionally a third thoracic lobe is present, joining the right with the left lobe. The vena innominata has been found to pass through the gland in a few instances. Cooper recognized the great frequency of anomalous shapes and positions of this gland and its anatomical relations. The left is often larger than the right gland.

Anatomical relations.—"After exposing the mediastinum the thymus is found to be situated behind the first and part of the second bone of the sternum and posteriorly to the origins of the sterno-hyoidei and thyroidei muscles and extending downward to the fourth rib at birth, and upward into the neck near the thyroid gland. It is attached to the sternum and origins of the sterno-hyoidei and throidei muscles by cellular tissue, and adherent to the pericardium by coarse cellular tissue, and anteriorly and laterally the internal mammary arteries and veins take their course.

"The reflection of the pleura descending from the cartilages of the ribs on one side, and continued to the fore part of the pericardium, forming the anterior mediastinum, makes its lateral boundaries and separates it from the lungs; posteriorly it rests upon the vena innominata, and upon the fascia of the thorax which descends from the sternum and first rib to the curvature of the aorta, and to the three large vessels which spring from it, the arteria innominata, the left carotid, and left subclavian arteries."

The gland is supplied with blood directly from the internal mammary and inferior thyroid arteries.

Neck relations.—"After turning aside the platysma myoides and external jugular vein, and elevating the origin of the mastoidei muscles, the sterno-hyoidei and thyoidei muscles appear crossing and passing over the thymus gland. Upon removing these muscles, the gland may be seen on the anterior and lateral surfaces of the trachea and just below the thyroid gland, where it passes on the fascia on the fore part of the trachea and unites with the larynx by a ligament.

"The internal jugular veins are placed anteriorly and laterally to the cervical portion, and the carotid arteries with the par vagum appear more externally.

"The first horn of the sternum and sternal ends of the clavicle cover the junction of the cervical with the thoracic portion of this gland. Cooper states that he has found the gland higher upon the right side in many cases."

The gland is in the superior mediastinum, and in the neck, sometimes high enough to be connected with the thyroid gland. Deaver states that he has met this condition when performing low tracheotomy; it rests upon the transverse aorta in the mediastinum. In the adult it is represented by a small, brownish, fatty body lying just above the arch of the aorta and in front of the innominate, the left subclavian and the left common carotid arteries.

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PHYSIOLOGY.

Physiologically the thymus gland, like the tail of the tadpole, is of more importance to the foetus and infant, less so to children, and not at all to adults. Its function is not known. Energetic experimental work has not added much to discovering the physiology of this gland. Possibly it is only useful during the nursing period, or of greater importance in utero. We find the following analysis of M. Friedleben's work on this gland in the *Medical Times and Gazette* of July 23, 1859:

Anatomy.—(1) The thymus is a gland without any external duct; it is composed of an infinite number of lobules, each one consisting of closed follicles, united together by a very fine cellular tissue. (2) Its nerves are the nerves of its vessels, and proceed from the ganglions of the sympathetic nerve. (3) The thymus has no free cavities; what have been taken for cavities are interlobular intersections. (4) It contains a secretion composed of a clear, transparent fluid, holding innumerable round nucleoli in suspension, mixed with some cells. (5) The nucleoli pass directly into the veins of the thymus. (6) The follicles of the thymus continually perish and are renewed; the bodies which have been called concentric are only follicles during their metamorphosis. (7) The thymus increases continually from its embryonic origin up to the age of puberty; but its increase is relatively less than that of the body. Between the ages of fifteen and twenty-five it remains stationary. It begins to diminish in volume at the end of this period, rapidly decreasing in adult life. After this period the thymus is rarely met with, and only in the form of fatty tissue.

The effect of the Roentgen rays on the thymus.— That Roentgen rays produce distinct changes in various tissues of the animal body is well known, but concerning the exact mechanism by which these changes may be produced in the blood and blood-forming organs by these rays under proper conditions, and, as first shown by Heineke, the lmphocytes are especially sensitive to their action, disintegration taking place very rapidly. It is on this account that the rays are used in the treatment of leukaemia. In animals it has been found that the lymphoid tissues themselves are markedly affected. Recently the effect of Roentgenization on the thymus has been studied experimentally by Rudberg. (Om Thymusinvolutionen efter Rontgenbestraining Jamte Nagre Iakttragelser Ofver Leukolysen i Ofright Hos Rontgenbestralde Djur. Af. Hans Rudberg, Upsala, 1909) and as the resulting cellular changes have been followed closely (in rabbits) a brief account of them is given.

Under the influence of the rays the lymphocytes as well as the cells of the reticulum of the thymus rapidly undergo a characteristic destructive process which sets in with disintegration of the lymphocytes within three and one-half hours after beginning the exposure. The products of disintegration, as a rule, do not leave the thymus, but are taken up by the cells of the reticulum and subjected to intracellular digestion, and in from twelve to forty-eight hours all lympocytes and lymphocytic remnants may have disappeared. The reticulum now becomes closely approximated, and the tissues assume an epithelial aspect. Degeneration of the reticulum cells takes place somewhat later, often after all lymphocytes have been destroyed, and continues after the regeneration of lymphocytes has begun. The reticulum-cells are changed into large transparent forms with pronounced foamy structure. Large parts of the thymus may become sequestrated, and through softening of the dead tissue cystic cavities may arise. If the destruction has been moderate only, the regeneration which follows is accomplished by the reticulum cells as well as the lymphocytes still present. But if prolonged exposures are made, then all the lympho-

cytes may be destroyed, and now the new lymphocytes appear to come by importation through the lymph-vessels, passing into the perivascular connective tissue to the center of the lobules and spreading themselves out towards the periphery. Later, these cells multiply, and after a time the division of the parenchyma into cortex and modulla becomes apparent again.

Marked changes in the thymus occur when it is protected against direct action of the rays by means of lead plates. In this case there is not only some disintegration of lymphocytes, but also an emigration. The latter takes place in the usual method characteristic of accidental thymic involution and inanition, the lymphocytes wandering into the medulla and entering the lymph-vessels there. The emigration begins early and is most marked before the animal begins to show signs of diminished vitality and less of body weight, and consequently has no connection with the thymic involution which may result from disturbances of the general condition of Roentgenization. It seems that the cells emigrate in order to replace cells that have been destroyed elsewhere in the body and in the blood, and in consequence the number of lymphocytes in the blood increases. The disintegration of the thymic lymphocytes in animals whose thymus is protected takes place during the first day after irradiation, and is similar to that which follows direct irradiation, but is less extensive. The cause is ascribed in part to a secondary irradiation from the neighboring parts of the body, which have been exposed to the rays, and no doubt is some part to the action of lymphocytolytic substances which appear in the blood and tissue-fluids. This secondary irradiation is easily shown by placing a photographic film under the lead plate. That lmphocytolytic substances are produced was shown by Rubberg by injection of the blood and serum of irradiated animals into the peritoneal cavity of healthy animals, in which there resulted a distinct disintegration of lymphocytes in the follicles of the appendix and mesenteric lymph-nodes.

At present we must be satisfied with knowing that Roentgen rays cause the remarkable changes that have

been described; how they cause them is a mystery.—Editorial, *Journal American Medical Association*, February 25, 1911.

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EXPERIMENTAL.

Experimentally the thymus-gland has been frequently considered anatomically, physiologically and surgically, but aside from its anatomical and surgical aspects little is known, nothing definite having been discovered physiologically. The glands of the various forms of animal and insect life have been extensively considered. Their influence upon the sexual organs, the blood, the brain, the nervous and the digestive systems have all been subjects well calculated to occupy the minds of scientists.

Personal Observation.—Fish: Salmon, Carp, Bluecat, Mudcat, Bass, Sturgeon. Reptiles: Snakes, Tortoise, Turtles. Birds: English Sparrow, Chickens, Robin, Pigeon, Quail, Lark, Catbird, Owl, Hawk, Crow. Mammals: Human, Rat, Mice, Cat, Dog, Rabbit, Squirrel, Calf, Sheep, Pig.

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DIAGNOSIS.

Diagnosis of an enlarged thymus is becoming less difficult with improved methods, and it is well established that persistent and enlarged glands are more frequently recognized in both children and adolescents. It has but recently been discovered many times to be associated with glandular enlargements and tonsilar hypertrophy or both. Percussion signs and the X-ray are the most important and definite means. Slight percussion in the first and second interspaces to the left of the manubrium, sometimes on both sides, will define the outline, but percussion on the right side alone is indefinite. It may be differentiated from enlarged mediastinal glands by:

1. *Superior and more superficial position.* 2. Common position to the left of the manubrium. 3. By a special maneuvre which depends on the movable character of the thymus and its attachments to the lower pole or poles of thyroid. 4. This maneuvre consists in placing the patient in a sitting posture, with the chin depressed; outline the lower border of thymus dullness; then, while pleximeter fingers were kept exactly in place, the head should be sharply retracted to the fullest extent. Thymus dullness rises upward toward the neck, leaving clear percussion resonance. Mediastinal adenitis, aneurysms, and neoplasms did not give this shifting dullness. (Boggs.)

Dr. A. Jacobi, of New York, had always found that he could with great facility diagnosticate the size of the thymus. A good many of these glands at birth were only from a few grammes up to ten, thirteen and fifteen grammes in weight. They were not easily recognized when the infants were sitting up or lying down, but they were recognized when the infant was bent

over. Dr. Jacobi has been teaching this method for the last fifteen years.

Medical treatment.—(1) X-ray; (2) Radium; (3) Serum.

X-ray: Lang (Lancet-Clinic, Apr. 22, 1911) reports several cases of enlarged thymus glands treated with the X-ray, which are not considered as status lymphaticus of Paltauf; while the X-ray will cause hypertrophy to become less if not entirely disappear, but few remain so, regeneration being the rule; improvement usually results, gradually becoming greater. It is always difficult to determine the size of a gland with the X-ray, especially the antero-posterior diameter; for this reason the progress of the treatment is difficult to determine. The X-ray appears to be a valuable adjunct in the treatment of diseases of the thymus whether surgical or non-surgical, thus indicating its employment under most circumstances. It is said to be harmless.

This remains a mooted question. The location of the thymus being in the superior and anterior mediastinum makes opportunity favorable for the application of the rays.

Radium having been known to have a specific therapeutic effect upon neoplasms, has been suggested in the various pathologic conditions of the thymus; it should be applied directly to the gland at intervals varying in time and duration of frequency by means of thoracotomy or thorectomy by flap or trephine.

Serum in the treatment of thymus hypertrophy has not been carried beyond experimentation, but as it has been beneficial in the treatment of other glandular affections it is reasonable to suppose it will be found to be beneficial if not curative in this diease.

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SURGERY.

1. Intubation. 2. Tracheotomy. 3. Thymotomy. 4. Thymopexy. 5. Thymectomy. 6. Thymorraphy.

Surgical aspects.—The supposed disappearance of

this gland before the age of fifteen years has been confounding to operators in having to reckon with it surgically in adult life, because of its relations and its remnants undergoing changes of a more or less serious nature. It is therefore a gland of great surgical importance in infants and adults, but more especially during the first fifteen years of life.

It may be necessary to attack it because of injury or disease. The effects of a large thymus due to any cause are almost purely mechanical. The sternum may be pushed perceptibly forward, or the neck upward, or both conditions may exist at the same time; it may be pushed backward and downward, or laterally, depending upon its size and the resistance of the sternum and soft structure of the neck. Its density may influence the direction of pressure, which is in the direction of least resistance. Pressure may be directed upon the blood vessels, trachea or pneumo-gastric nerve, single or combined. The gland is surrounded by a loose capsule which is easily distended.

Intubation is resorted to as the simplest palliative measure, one that any novice may do with a rubber catheter if other means are not at hand. Intratracheal rubber tubes are also effectual, but any tube should be open at the end and not laterally. They may be introduced without local anesthesia, seldom if ever pulmonary anesthesia.

Tracheotomy is second in choice to intubation as a palliative measure, many times necessitating the continuance of a tube varying in length, within the trachea, sometimes extending to within one inch of the bifurcation of the bronchial tree. This operation should be done with local anesthesia, but if necessary may be done without anesthesia of any form, local or general.

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Thymotomy is done for cysts containing blood, pus or serum, and the removal of foreign bodies.

Technique.—Make a median incision extending from the cricoid to a point a little below the sternal notch,

divide the soft parts by blunt dissection, down upon the gland. The tumor will then present itself. Open capsule and withdraw the gland. If no lesion is found, without evidence of further necessity for direct surgical procedure, the gland may be returned, the opening in the chest closed, with or without drainage, usually with drainage.

Thymopexy.—With the presence of a cyst of any character the lips of the incision in the gland may be fixed in the thoracic opening by suturing the gland, and its immediately surrounding tissues to the edges of the soft structures of the wound so that drainage may be continued indefinitely. This procedure will often relieve all symptoms.

Thymorrhaphy.—Suturing of the thymus is done for incisions, lacerations, ruptures and punctures. Small, heavy, sharp, curved needles carrying fine silk or linen or long-lifed catgut as small as can be conveniently supplied, should include as much tissue as possible, the sutures being uninterrupted.

Thymectomy.—If extirpation is necessary the gland may be readily delivered, and the blood vessels ligated before they enter the upper pole, and the gland thus be removed with but little difficulty. Since Rehn (1896), who was the first to remove the thymus gland, several operators have removed a score or more of such glands, improvement being the rule. The mortality has been but slight.

Ransohoff states that he saw a patient from whom Durante (1906) had successfully removed a sarcoma of the thymus including a portion of the innominate artery one inch in length.

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STATUS LYMPHATICUS.

Status lymphaticus does not always necessarily mean that the gland is enlarged; it may or may not be so; nor does an enlarged gland necessarily indicate a status lymphaticus.

Lang says: "Drawing my conclusions from cases recorded in the litetrature, thymus deaths may be grouped under three headings. The first group includes those cases in which there are actual pressure-symptoms appearing some time before death, and the post-mortem reveals evidence of pressure upon the mediastinal contents. In the second group, the thymus, while enlarged, does not produce any prodromal pressure symptoms during life, and the post-mortem shows enlargement but no actual signs of pressure. The fatal issue in these cases is explained by a sudden swelling of the thymus due to some exertion, as in crying, or due to some interference with the circulation, as produced by certain positions of the patient, as would occur in giving an anesthetic. In these cases a vicious circle is established. In addition to the swollen thymus

the mediastinal veins become distended and the heart dilated, which again react on the swollen thymus, the combination producing death.

In the third group the deaths are extremely sudden, without evidence of mediastinal pressure of any kind. Upon autopsy the thymus may or may not be enlarged. This group includes the true status lymphaticus of Paltauf and the cause of death is according to Svehla's theory and experiments in "hyperthymization."

Burns described thymic asthma and said that it was probably due to pressure of an enlarged gland, or what has recently been termed by Paltauf "status lymphaticus."

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No doubt many of the undetermined origins of mediastinal pathology should be ascribed to the thymus gland or its rudimentary structures. Anatomical relations are changed so materially when large neoplasms are present, that it is often absolutely impossible to

assign their origin, especially after the glandular structures have become absorbed as the result of age or disease. Spontaneous cure having not been infrequent, ante- and post-mortem appearances are so greatly at variance that much time and observation will be necessary to determine certain facts. Color, consistency, size, area involved, and bloodless conditions are markedly different in death than in life.

Pathology.—The thymus is as versatile as any other tissue of the body except the cutaneous structures. This is evidenced by the presence of congenital hypertrophy, abscess, cysts, tuberculosis, syphilis, naevus, hemorrhage and haemaphilia (direct or indirect), epithelioma, myxoma, lipoma, fibroma, lymphodenoma, and various other types of sarcoma. Any of these conditions may be found in infant or adult life. When in the adult, a belated gland has been the cause.

The following brief review of seven cases of hyperplastic thymus, reported by Dr. Audre Crotti, of Columbus, Ohio (Jour. A. M. A., Feb. 22, 1913), is most interesting.

Certain cases of asphyxia of new-born babies are explained only by thymus hyperplasia. The child is born apparently dead, and it often takes quite a long time to reanimate it; its breathing is difficult and loud. It remains cyanotic and in many instances dies after a few minutes or hours. The autopsy shows only asphyxial lesions and an enormous thymus displacing and compressing the wind-pipe—no cardiac malformations, no cerebral hemorrhage, possibly only a few subpleural and subpericardiac hemorrhages.

The most striking symptoms of thymus hyperplasia is dyspnea. This may be characterized by only a labored respiration or by the most intense choking spell. Between these two extremes all forms of transition are found. Dyspnea may be constant or intermittent, with or without acute paroxysms. Between attacks, respiration may be entirely normal. There may be a constant and persistent inspiratory stridor, and in extreme dyspnea an expiratory stridor also, which is, however, less marked. In paroxysmic dyspnea the child suddenly suffocates and becomes cyanotic. The

stridor is extremely marked, respiration becomes accelerated, and there is a sucking in of the suprasternal and infrasternal fossae. The choking spell may occur without cause, or when the child cries from pain or anger. Hyperextension of the head or dorsal decubitus exaggerates dyspnea. This would explain why dyspnea is more marked during sleep than during waking hours.

These paroxysms of dyspnea are extremely alarming to witness, and there is a great temptation to perform a tracheotomy. In such cases tracheotomy is useless, because the tube used is too short, the pressure taking place lower down in the thorax. From now on, every tracheotomy outfit should have tracheotomy tubes long enough to reach the bifurcation of the trachea. An interesting fact of the thymic dyspnea is that the voice is normal during the paroxysms as well as between. The choking spell may last a few minutes, a few hours or a few days, and then respiration becomes normal again. In other cases death ensues. In certain cases the child dies at the beginning of the choking spell.

This dyspneic condition begins, as a rule, in the first weeks or months and diminishes the second year of life, and is more seldom found after this period. This may be due to the fact that the gland normally retrocedes after the second year of life and that the superior opening of the thorax becomes larger with the growth of the child.

The spell of suffocation is due to compression of the wind-pipe by the thymus hyperplasia. The trachea is compressed to a more or less marked degree; the posterior wall of the trachea comes in contact with the anterior, so that there is very little or no space at all for the passage of air. The trachea may be compressed and displaced at the time, especially toward the right side. When the trachea has been released from the pressure of the thymus the flattening may remain; but in certain cases, especially in younger children in whom the trachea has kept its normal elasticity, the trachea resumes its normal caliber. This is especially true in chronic and in intermittent cases.

Pressure on the wind-pipe by the thymus takes place

at two different points. The first point of pressure is found between the posterior surface of the manubrium sterni and the first and second vertebrae. At the superior opening of the thorax of a child the anteroposterior diameter measures only 2 cm., and as a rule the hyperplastic thymus measures more than 2 cm. in thickness; as the superior opening of the thorax is absolutely rigid and can not increase its diameter, the thymus coming up like a wedge between the sternum and the spinal column will naturally compress the wind pipe. A finger placed behind the episternal notch feels the impact of the rising thymus. If the superior opening of the thorax can not increase its diameter, it can, on the other hand, diminish it; for instance, in the hyperextension of the head. In such cases the vertebrae are projected forward, and in so doing diminish the anteroposterior diameter of the superior opening of the thorax. This would explain why in certain cases death has followed such a position.

Another point at which the compression of the windpipe may take place, too, especially in adults, is the point situated between the brachiocephalic trunk and the left common carotid. This compression is not confined to one ring of the trachea alone, but extends over a certain portion of it. This is easily understood when we consider the anatomic relations of the thymus with the trachea in that region. As the thymus presses on the anterior surface of the trachea in the space between the left common carotid and the brachiocephalic trunk, and as the trachea lies in front of the spinal column, in cases of sudden enlargement, the thymus will exert a compression on the trachea, being itself compressed between the spinal column and the sternum.

Case 7, July 10, 1912.—Female baby, 7.5 lbs., delivered by Dr. Rogers with forceps. The baby required no effort at resuscitation, breathing at once and crying lustily, and was apparently normal and treated as such. The ordinary cyanosis at birth was present and passed off in the ordinary period of a few minutes' time.

At 2 P.M. the baby had what was described by the nurse as a choking spell. It turned blue, seemed to have difficulty in getting its breath, and gasped. This

spell yields to the ordinary treatment of the nurse for cardiac and respiratory failure, namely, suspension by the feet, flagettating of the buttocks and splashing of cold water over the bare thorax and body. The attack lasted only a few moments and the baby again appeared to be all right and was placed in the nursery with the other babies. About 8 P.M. another attack occurred, more profound and serious; baby again turned blue, gasped for breath and "moaned" as the nurse said, in a peculiar way, heard only once before in her experience in the case of a baby that died a few hours after birth from the so-called persistent patent foramen ovale. A whistling sound on both inspiration and expiration grew fainter and fainter, and in spite of efforts at resuscitation the baby died. This attack lasted only 15 minutes.

Percussion of the thorax showed a dullness over the manubrium sterni fusing downward with the cardiac dullness. It extended 2 cm. beyond the left sternal edge and 2.5 cm. beyond the right sternal edge. The dullness extended down to the sixth intercostal space 0.5 cm. from the right sternal edge and 0.5 cm. from the nipple; above the episternal notch no resistance was felt.

Tracheal stenosis is frequently due to direct pressure of the thymus gland and usually occurs between the second and fourth ribs. However, some deaths following dyspneic symptoms have been shown to be caused by a spasm of the glottis due to the stimulation of the constrictors of the glottis by stretching and pressure displacement of the inferior laryngeal nerve. Or death may occur suddenly by the enlarged thymus pressing upon the base of the heart.

Congenital stridor and respiratory disturbances due to enlargement of the thymus must be differentiated from those caused by adenoids, laryngeal deformities and tracheobronchial glands. Adenoids, although producing difficult and labored breathing, such breathing is more severe at night and may be diagnosed by reflected light.

Stridor due to tracheobronchial glands is acquired,

not congenital. Voice changes and percussion symptoms vary greatly from those of thymic-stridor.

Congenital vestibular stridor is inspiratory. Cyanosis disappears on intulation of larynx, appears after birth, and on direct examination shows deformity of the superior opening of the larynx, which causes stridor.

The first form of compression which takes place at a superior opening is found mostly in children.

The second or thoracic form, which takes place between the bracheocephalic trunk and the left common carotid, is found mostly in adults.

In some cases, when autopsy has been held, a very large thymus may be found with no evidence or history of ever having caused symptoms. Extensive investigation has proven that there is in a great majority of cases a hyperplasia of the thymus gland in all affections of the thyroid gland.

Injection of a watery solution of thymus gland into animals, while if frequently repeated cause death, yet have proven no special action of such solution over that of other tissues. Although many theories as to the action of the thymus gland have been advanced, we do not yet know its action.

Transplantation of pathologic thymus into normal tissue will cause symptoms characteristic of such tissue in the original subject.

The relation of the thymus to the thyroid gland is an object of much discussion at the present time. Some authorities claim that they work harmoniously and compensatorially, while others claim that they have an antagonistic action.

Our knowledge of the uses and action of those glands will undoubtedly be increased in the years to come and their value to the human organism demonstrated beyond a doubt.

PATHOLOGY.

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CHAPTER XV.

SURGERY OF THE LYMPHATIC GLANDS AND CHANNELS.

The thoracic duct is found in the loose tissue between the vena azygos major and the aorta; it is very elastic, and the size of a whip-cord. It sometimes becomes diseased or injured by violence or surgical operation to such a degree that ligature or suture becomes necessary. However, injuries have been known to close without surgical intervention. That suture of a recent lateral or end to end anastomosis with the inferior vena cava be made, it is necessary that an opening in the chest be made of sufficient size by excising the ribs or making a periosteo-cutaneous flap.

Anatomy.—The thoracic and right lymphatic ducts constitute the lymph ducts of the chest. The larger of the two, known as the *ductus thoracicus,* originates in the receptaculum chyli at second lumbar vertebra and finds its course upon the vertebral column slightly to the left of the median line, to the neck, where it deviates to the left almost at a right angle, immediately in front of the vertebral artery and behind the left subclavian vein.

A careful review of the lymphatics of the thorax indicates that something more than surgical measures are necessary to cure certain types of malignancy when far advanced in the thoracic and intra-thoracic tissues. This is especially true with the mammary gland, which is the most frequent location for cancer in any of these structures.

Lymphatic glands of the thorax are divided into two groups, designated by parietal and visceral.

The cutaneous lymphatics have been divided into anterior, posterior and lateral.

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*An illustrated lecture delivered to the Students of the American Medical College, St. Louis, Mo., April 19, 1911.

The division of the lymphatics into anterior, posterior and lateral is not strictly correct, since the lymphatics may pass beyond the boundaries described. New channels may be found, and they may, because of neoplasm and thrombus, direct the flow in the directions which are not normal for the lymphatic channels in that region. For example, the terminal point of the cutaneous lymphatics of the thorax may be in the inguinal region instead of the axillary (Gerotu).

The anterior cutaneous group extends from the median line to about the anterior axillary line. They drain the thorax to and below the xiphoid cartilage, while above they drain above the clavicle. In the median line the lymph-trunks may overlap each other. These channels terminate in axillary and supra-clavicular glands. The anterior cutaneous have four channels, viz: homolateral, one each side, subclavian and internal mammary; the homolateral is the principal channel.

Lateral group.—The lateral group arises by five or six trunks and ascends vertically, terminating in the thoracic group of axillary glands; along the course of these trunks the axillary aponeurosis is perforated.

Posterior cutaneous group.—There are ten or twelve lymph trunks in the posterior cutaneous group (Sappey). The lower trunks drain the lower thorax and a little beyond. The dorsal region is drained by the middle trunks to a point near the middle line. The upper trunks drain the lower neck and terminate in the scapulary group of the axillary glands.

Lymphatics of the external intercostal muscles.—Are more developed than those of the internal intercostal muscles (Sappey).

Trunks branch off from the external intercostal lymphatic glands and accompany the intercostal vessels and nerves. The nodules along their course are called lateral intercostals. Some small branches originate in the muscles attached to the external surface of the thorax. They accompany the perforating branches of the intercostal arteries. Most of the lymphatics of these muscles empty into the axillary glands. There is a union of the internal and external lymphatics.

Intercostal lymphatics, internal.—The lymphatics of the internal intercostal muscle receive the lymphatics from the parietal pleura. They give off oblique branches, which ascend and pass forward in the subpleural cellular tissue along the lower borders of the ribs. In the six or eight upper spaces the trunks individually terminate in the glands of the internal mammary chain or into the chain uniting these glands. The remaining spaces unite and form a single trunk which reaches the lower portion of the mammary chain.

Thoracic visceral glands.—The visceral glands are divided into three groups, viz.: Anterior mediastinal, peritracheo-bronchial (middle group), and the posterior mediastinal.

Anterior mediastinal glands.—The anterior mediastinal glands are in the upper part of the anterior mediastinum. They number from four to six, and are placed upon the anterior and convex portion of the transverse aortic arch. Passing from these glands are two trunks which are found on each side of the neck. They are arranged differently on each side and accompany the corresponding blood vessels.

The right chain is in relation with the right innominate vessels. Some of the glands are anterior to the innominate. The left chain differs in its arrangements and corresponds to the blood vessels upon this side. The glands are arranged around and between the common carotid and the subclavian vessels.

Peritracheo-bronchial glands are between the anterior and posterior mediastinum. They were classified into four groups in Bariety's classical description of 1874, which was as follows: Right pretracheo-bronchial glands, left pretracheo-bronchial glands, intertracheo-bronchial glands, and interbronchial glands.

1. *The right pretracheo-bronchial glands* are located in the right tracheo-bronchial angle. They are about four or five in number, while in size they are as large as a pea. Their shape resembles an haricot bean. The surrounding structures have the following relationship to the glands: The trachea is internal, while the bronchus is inferior; the inferior vena cava lies anterior, the lung external; the pneumogastric nerve is pos-

terior; the subclavian arch is superior; the recurrent laryngeal nerve and its glandular chain are related to these glands.

2. *The left pretracheo-bronchial glands* are in the left tracheo-bronchial angle. In size they are smaller than those on the right, while their number is about three to four; anterior to the glands is the aortic arch. The trachea is internal, while the left bronchus and left pulmonary artery are inferior to the glands. To the posterior is the left pneumo-gastric. Superior to the glands is the aortic arch, a loop of the recurrent laryngeal and its accompanying chain.

3. *Intertracheo-bronchial glands.*—These glands are in the tracheo-bifurcating angle. Their number varies from about ten to twelve. Those under the right bronchus are larger than those under the left. The tracheo-bifurcating angle is superior to the glands. On the anterior side of the glands the left auricle, covered by its pericardium, is in relation to the glands; from this small venous tributaries flow from the glands. Posteriorly the anterior part of the esophagus and the pulmonary plexus is in relation.

4. *Interbronchial glands.*—These glands are located in the angles of the large bronchi. They are present in angles of the fourth order (Cruveilhier). Buried within the pulmonary parenchyma, these glands are in relation with the pulmonary blood vessels. The pulmonary artery is in most intimate relation.

The interbronchial glands may be enlarged from infection or neoplasms. Under such circumstances the pulmonary artery and vein may be compressed. Anthracosis is present during the earliest years of life. In later life sclerosis takes place, when they are replaced by fibrous blocks.

Posterior mediastinal glands.—The posterior mediastinal glands are located posterior to the pericardium and anterior to the esophagus. Rarely, two or three retro-esophageal glands are located laterally to the thoracic duct.

Pulmonary lymphatics.—The pulmonary have two kinds of collecting trunks, superficial and deep.

Superficial collecting trunks arise from a plexus,

which is subdivided into polygonal meshes, each of which corresponds to a sub-pleura lobule. The course of the collecting trunks varies, as the trunk of each lobule has a course of its own. Sappey has described them as follows:

(a) *Upper lobe.*—There are three groups of origin, one going around the posterior border of the lung, another around the anterior, while the third goes along the inferior surface of the lobe and penetrates the interlobular fissure. The three groups terminate in glands of the hilum.

(b) *Middle lobe* of right lung is less than the ones of the upper and lower lobes. Some of these trunks unite with the trunks of the upper lobe, while others unite with the trunks of the lower lobe.

(c) *Lower lobe.*—The collecting trunks are divided into three groups, viz.: Superior, posterior, and anterior. The superior trunks penetrate the interlobular fissure, while the anterior and posterior pass around the corresponding border of the lung; after reaching the internal surface they pass obliquely to the hilum.

Deep collecting trunks.—The courses of these trunks correspond to the sides of the bronchial ramifications, branches of the pulmonary artery and vein. The course of all is towards the hilum, their termination is the tracheo-bronchial glands (Miller).

Most authorities agree that the superficial and deep collectors communicate with each other. To this Miller takes exception, and claims that it is only rarely that the two trunks are connected.

VISCERAL LYMPHATICS.

Cardiac lymphatics.—The myocardium is the only part of the circulatory system containing lymphatics. These lymphatics are within the peripheral portions of the myocardium. They are called subendocardial and subpericardial.

1. *Subendocardial lymphatics.*—The subendocardial lymphatics are, as their name implies, the deeper lymphatics. They empty into the subpericardial network. As yet the subendocardial network has not been injected in man.

2. *Subpericardial lymphatics.*—The subpericardial lymphatics are the superficial group. So far it has not been demonstrated in man. Sappey has demonstrated them, however, in the ox and horse. They are divided into the anterior and posterior collecting trunks.

(a) *The anterior collecting trunks.*—There are two and occasionally three anterior collecting trunks. They have also been called the "left anterior collecting trunk." They arise from a point near the apex, run parallel to the anterior interventricular furrow, unite and form a single trunk, which passes between the left auricle and pulmonary artery, after which it lays upon the posterior surface of the pulmonary artery, perforates the fibrous layer of the pericardium and has an outlet in one of the groups of the intertracheo-bronchial glands. Several branches are received, along the interventricular course, from the anterior surface of each ventricle, as the left anterior collecting trunks pass along the interventricular furrow. They unite and form a single trunk which runs between the left auricle and the pulmonary artery, perforates the fibrous layer of the pericardium and empties into one of the groups of intertracheo-bronchial glands.

(b) *Posterior collecting trunk.*—This is also called the "right collecting trunk." It arises near the apex on the diapragmatic surface, passes along the inferior interventricular groove, then passes to the anterior surface by passing along the auriculo-ventricular groove. From this point it passes on its upward course between the aorta and pulmonary artery, terminating in one of the intertracheo bronchial glands. It collects the lymphatics from the posterior surface of the right ventricle and also from the right border of the same. The posterior collecting trunk also receives the lymphatics from the right auricle.

Anomalies.—Thoracic ducts and glands vary in diameter, length, location, number and size.

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Physiology.—The history of the lymphatic system is synonymous with that of the cardio-vascular system in both anatomy and physiologic secretions. Experiments are legion in attempting to settle these fundamental principles, until now they are as well established as any pertaining to human physiology.

PHYSIOLOGY.

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Paton, D. N.: Observations on the composition and flow

of chyle from the thoracic duct in man. J. Physiol., Cambridge, xi, 109-114, 1890.
Iosifoff, G. M.: Importance of dilation at the beginning of the thoracic duct for the lymph movement. Russk. Vrach., S. Petersb., iii, 1909.

Experimental.—Experimentally the lymphatic system of the thorax, like that of other regions, has been extensive and satisfactory. However, that pertaining to progressive glandular infection remains quite undeveloped. This is found to be so with malignant growths, their extension into certain groups of glands not always obtaining, causing wonderment. If the accepted rule of extension predominated, all malignant growths upon or within the thorax would become general, so that there would be no necessity for resorting to surgical measures of any kind or degree.

History.—Bartiolinus (1653) is one of the earliest to experiment upon the thoracic duct, while Cooper (1798) mentions three instances of obstruction to the thoracic duct, with experiments showing the effects of tying that vessel, and Amussat (1840) mentions an extraordinary development of the thoracic duct. Uspensky (1888) records interesting experiments by ligating the thoracic duct to determine the effect on chemical and morphological substances of the blood. Sujeff (1889) ligated the duct of a dog to determine the effect upon nitrogenous metamorphosis, and Trushennikoff (1891) ligated the duct to determine its effect on exchange of gases in animals.

EXPERIMENTAL.

Bartholinus, T.: De lacteis thoracis in homine brutisque nuperrime observatis historia anatomica, Parisiis, 1653.
Bartholinus, T.: Dubia anatomica de lacteis thoracic et hepatis, Parisiis, 1653.
Cooper, A.: Med. Rec. Private M. Assoc. Lond., 86-115, 2 pl., 1789.
Amussat et al: J. de physiol. exper. Par., x, 22-35, 1830.
Uspensky, A.: St. Petersb., 1888.
Sujeff, A. J.: St. Petersb., 1889.
Trushennikoff, N. V.: St. Petersb., 1891.

Diagnosis.—Diagnosis of irregularities of the thoracic lymph system (glands and channels) due to injury and disease, is, as a rule, difficult.

Injuries not only cause the ducts to be opened, but

the glands to become enlarged. Obliteration of the intercostal spaces, dullness upon percussion, disturbed respiration and cardiac function indicate the presence of fluid within the thoracic cavity. Such a condition, immediate or remote from the injury, is suggestive of laceration of the lymphatic channel, which can only be determined by aspiration, especially in the absence of temperature. If the presence of chyle is determined by this method, such an injury is certain.

The presence of chyle may also be the result of rupture of the duct due to pathologic organisms alone or combined with injury.

Glands when hypertrophied may be due to injury or disease; they vary in size, number and location. Their presence when intrathoracic is difficult to determine, though when large they may be detected by means of the X-ray. Those most easily found are of the bronchial group.

DIAGNOSIS.

Smith, A.: Peut-on diagnostiquer l'obliteration de la citerne du chyle? Scalpel, Liege, lii, 224-225, 1900.

Surgery.—Not only glands, but terminals must be considered in the surgery of the lymphatics, because infection of the glands and channels occur alike.

History.—History of surgery of thoracic lymphatic system is of recent origin, one of the earliest reports being that of Keen (1894), who reports a resume of four cases of wounds of the thoracic duct in the neck, all having been operated upon. Jesus (1895) records a case of ligation of the thoracic canal. Schwinn (1896) mentions an injury to the thoracic duct at the root of the neck during a surgical operation. Nattan-Larrier (1897) describes the technique for ablating this canal, while Cushing (1898) reports a case of operative wound of the duct which he repaired by suture, and Deanesly (1903) one in which he implanted the divided thoracic duct into the internal jugular vein with recovery. Thus there are in evidence sufficient data to warrant the assertion that the thoracic ducts are subject to the same surgical principles that govern veins and arteries, and that it will not be

long until the number of operations for their repair will be legion. Suturing incisions, lacerations, punctures by foreign bodies and end to end and lateral anastomosis will obtain to the same degree. That the thoracic ducts may be exposed for surgical repair, it is necessary to approach them through the neck or by means of a trans-thoracoplasty. (See Thorocoplasty.)

Technique.—The rules for suturing blood vessels obtain in surgery of the thoracic duct. (See Arteriorrhaphy.)

SURGERY.

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Deanesly, E.: Lancet, Lond., ii, 1783, 1903.

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Reitz, Bruno: Zur Casuistik der Verletzungen des ductus thoracicus mit besonderer Berucksichtigung der operativen Eingriffe (Rostock), 1907.

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Wilms, M.: Traitement de l'embolie graisseuse par le drainage temporaire du canal thoracique. Semaine med. Par. xxx, 138, 1910.

TRAUMA.

History—Though the thoracic ducts have been subjected to the same variety of injuries as the blood ves-

sels, but little attention was given them in literature until Cayler (1865) reported a case of obstruction and rupture of the receptaculum chyli resulting in peritonitis. Cheever (1875) reported a probable wound of the thoracic duct while excising the clavicle for the removal of a tumor of the neck, and Kirchner (1885) one of rupture resulting in chylothorax. Eyer (1891) records an injury of this duct resulting in a unique and inevitable death by inanition; Lyne (1898) one of a stab-wound of the duct resulting in recovery, and Fullerton (1906) a wound of the duct which was ligated and resulted in recovery.

Injuries of the thoracic duct are of great variety, both surgical and traumatic. It may be partially or completely severed by blunt or sharp instruments or missiles of various kinds, or it may be partially or completely severed in fractures of the spine or erosion resulting from pathologic organisms. It may be partially or completely obliterated by pressure resulting from neoplasms of the soft or bony structures or foreign bodies. It is always an important factor when dealing with intra-thoracic structures, especially those in close proximity to it. Namely: the vertebra from behind the esophagus, bronchus, and aorta in front and to the side. It is of the greatest importance in surgical operations upon the deep structures of the neck and that portion of the diaphragm through which it passes. All penetrating wounds of the lower neck should be thoroughly considered from this point of view, and they should not be permanently closed until all suspicions of injury to the duct have been eliminated.

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Thorne, J. M.: Guy's Hosp. Gaz., Lond., x, 202, 1896.
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Horodynski, W.: Wound of the thoracic duct; recovery. Gaz. lek. Warszawa, 2, s. xxv, 796-798, 1905.

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Vitlin, V. L.: Injuries to the thoracic duct in cases of chylothorax and chylous ascites in connection with anatomical and experimental data on the chyliferous system. Kharkov. M. J., vii, 87-112, 1909.

Fistulae.—Fistulæ result from disease or injury and are exceedingly annoying and difficult to remedy. The fluid usually first escapes into the posterior mediastinal space, from which it may escape into one or all cavities of the thorax, including that of the pericardium, the bronchus, to be expectorated by the mouth or through the esophagus, to flow into the stomach, perforate the diaphragm to occupy the abdominal cavity, or it may escape by a fistulous tract through the cutaneous structures of the trunk. Dr. C. A. L. Reed (Cincin. Lancet-Clinic, pp. 341-342, Sept. 1, 1911) reports a chylous sinus resulting from a pan-hysterectomy (1909). He diverted the chylous fluid into the alimentary tract at a point corresponding with the recto-sigmoidal junction, after it had flowed into the vagina for two years.

FISTULAE.

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Japdelli, G.: Ein neues Verhafren zur Anlegung der indirekten Fistel des ductus thoracicus durch die vena subclavia.

Kuttner: Ueber einen Fall. von Chylusfistel nach Durchtrennung des ductus thoracicus am Halse. Munchen med. Wchnschr., liii, 99, 1906.

Pathology.—There is enough pathology found in the thoracic and intrathoracic tissues to offer the greatest encouragement, without further waste of time, upon that which, like cancer, offers no hope for surgery alone, unless possibly it be in the pre-cancerous or very earliest cancerous period.

History.—One of the first pathologic conditions of the thoracic duct to be recorded is ossification, it having been observed by Cheston (1780). Since then but little has been written upon its pathology, though Andral (1824) wrote somewhat extensively upon the history of the various maladies affecting this duct. Albers (1836) observed what he termed an aneurysm of the duct, and Adams (1849) a condition of suppuration due to inflammation, a condition also observed by Worms (1859) and Chauppe (1873).

PATHOLOGY.

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Worms, J.: Gaz. hebd. de med. Par., vi, 279-282, 1859.
Chouppe, H.: Paris, 1873.
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Hypertrophy.—The ducts and glands frequently undergo hypertrophic and degenerative changes, aggravated by irritation and infection, especially those of tubercular origin. All diseases of the respiratory system are more or less the exciting cause.

Symmers, N. (York M. J., May 20, 1911): "In lymphatic leuchæmia enlargement of the cervical nodes commonly occurs, in which event the blood-examination usually suffices to establish the nature of the enlargement. But in psuedo-leuchæmia there are no characteristic alterations in the blood and microscopical examination of the affected nodes reveals no criterion by which the changes may be distinguished from lymphatic leuchæmia or from those instances of diffuse hyperplasia or lymphoid cells in which tuberculosis as the etiological factor is presumptive rather than demonstrable. In this connection it can not be too strongly emphasized that psuedo-leuchæmia is to be distinguished from Hodgkin's disease, since the latter is associated with histological changes which render its recognition practicable in almost any circumstance.

"While Sternberg originally advanced the view that the histological alterations in Hodgkin's disease are invariably tuberculous, he has since admitted that this assertion is too far-reaching, but nevertheless continues to hold that considerable numbers of such cases have something in common with tuberculosis from an etiological standpoint, and that all of them represent the expression of a chronic infective process. Although the histological changes constantly encountered in Hodgkin's disease certainly indicate that the lesion is a granuloma, innumerable and varied attempts to demonstrate their tuberculous nature have failed to yield convincing evidence. Such efforts have included the administration of tuberculin in living human subjects of the disease, and monkeys, of freshly emulsified tissue, and the staining of affected nodes for tubercle-bacilli. Latterly, however, Fraenkel and Much maintain that they have demonstrated in nine out of ten cases of Hodgkin's disease a gram-positive granular bacillus resembling the tubercle bacillus. In two instances guinea pigs that had been injected with emulsified nodes died of tuberculosis, and apparently the same bacillus was detected in the organs. Acid-fast organisms, however, could not be shown.

"It is manifest, I think, that the cases just described presented no clinical standard by which they might have been differentiated from several other affections characterized by enlargement of the cervical lymph nodes. At the same time the histological diagnosis was scarcely less difficult on account of extensive hyaline changes in the stroma, resulting in almost total obliteration of the cellular details by which Hodgkin's disease is distinguished. Morphologically, the alterations in the stroma were strikingly like those encountered in the so-called amyloid degeneration, but, among other things, failure to obtain the reactions characteristic of amyloid material served to modify or even to dispel this suspicion.

"Finally, it is perfectly natural to assume that, in certain circumstances, the sclerotic changes in Hodg-

kin's disease may progress to such an extent as to dominate the histological picture, just as at other times the cellular features are so pronounced that the microscopical diagnosis is apparent at a glance. In the former event the changes are best interpreted, I belive, as an attempt at organization.

SECONDARY CHANGES IN OTHER VISCERA.

"In certain instances Hodgkin's disease does not confine itself to the lymphatic apparatus proper, but gives rise to the formation of secondary nodules in other viscera, notably the liver, in which event the histological changes are characteristic and differ only slightly, if at all, from those to be observed in the primary focus.

"The suspicion early arose that the secondary visceral nodules are of the nature of metastases and that the disease, if not primarily neoplastic, is at least capable of undergoing transformation with the assumption of malignant qualities. Against this view it is urged that the occurrence of such nodules is to be explained on the ground that the causative agent finds a favorable medium for activity in lymphomatous foci in the organs secondarily concerned. This explanation appears to be quite sufficient for the spleen and bone-marrow, but in certain other locations, notably the liver, kidney, lungs and suprarenal capsules it does not, at first, seem to be so readily applicable. But that the exception is more apparent than real would seem to be indicated by several facts. Thus in a case of primary abdominal Hodgkin's disease it has been shown that the eruption of secondary nodules in the liver was preceded by the appearance of small but definite lymphomatous foci in the region of the portal vessels, just as it has been demonstrated that the histological changes in the lymph-nodes are conceived in hyperplasia of lymphoid cells (Longcope, Symmers). That lymphomatous foci may arise in the liver is furthermore revealed by their almost constant occurrence in that situation in enteric fever and occasionally in glanders, while in primary gastro-intestinal pseudoleuchaemia they have been demonstrated not only in the

adventitia of the portal vessels, but in the lungs, esophagus, kidneys, pancreas, prostate, and adrenals (Herrick, Wells and Mayer, Hadden, Symmers). In my experience similar formations are of common occurrence in the connective tissue of the lungs, kidney, liver, prostate, pancreas and thyroid in various other pathological conditions, while in the routine histological examination of the adrenals lymphoid collections are very frequently encountered. Hence, it is justifiable to assume that in certain of these situations lymphomatous foci may play a part in the histogenesis of Hodgkin's disease, which seems to demand lymphoid hyperplasia as a prerequisite to development. At all events no one, as far as I know, has advanced adequate reasons for believing that the secondary nodules in genuine Hodgkin's disease arise from cellular transplantation, and in fact the suggestion does not seem to merit more than passing notice.

"On the other hand, the occurrence of secondary nodules in Hodgkin's disease is aptly comparable to deposits that occur in the same and other situations in the infective granulomata, especially tuberculosis and syphilis. Nevertheless there are those who regard certain of the secondary visceral manifestations of Hodgkin's disease as evidence of malignant transformation of a process that is primarily inflammatory. Thus, in a case reported by Karsner it is pointed out that the 'invading masses lose much of their inflammatory character (connective tissue overgrowth), take on a very rich cell-character, and also show little or no tendency to central necrosis.'

"Within very recent times other facts have been advanced in support of the contention that the inflammatory changes in Hodgkin's disease are susceptible of malignant transformation in that the new tissue is capable of invading surrounding organs and of establishing secondary nodules in distant tissues.

RESUME AND CONCLUSIONS.

1. "Primary disseminated epitheloid tuberculosis of the lmph-nodes, while rare, is by no means unknown. Its occurrence as an epiphenomenon in status lymphat-

icus, however, appears not to have been recorded, so that the case described in this communication would seem to occupy an unique position.

2. "The histological changes in Hodgkin's disease resolve themselves into three stages, the first of which is characterized by focal hyperplasia of lymphoid cells, and is succeeded among other features by the formation of multinucleated giant cells and interstitial connective tissue overgrowth. Although the lesion may not progress beyond this granulomatous stage, cases occur, as I have shown, in which the connective tissue-stroma undergo such extensive hyaline metamorphosis that the cellular details are obscured and the histological individuality of the process is established only with difficulty. This transformation would appear to represent an attempt at healing.

3. "A type of Hodgkin's disease exists, either primarily in the cervical region, or in the thorax, in which the growth may invade surrounding structures and initiate secondary nodules in distant parts. In either issue the process admits of at least two legitimate interpretations: First, that invasion of surrounding viscera may be referred to sarcomatous myeloid giant cells; thus neoplastic conversion would appear to be established beyond doubt.

"Bearing in mind the information gained from personal anatomical observations and histological studies of the case reported by Dr. Welch, I feel convinced that Hodgkin's disease is capable of transformation into a malignant neoplasm, and that the cases reported by Yamasaki, Chiari and myself represent illustrative examples in which the evidence, while highly presumptive, is not conclusive. In Dr. Welch's case I venture the opinion that the evidence of malignancy is conclusive."

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TUBERCULOSIS OF LYMPH NODES.

(Symmers, N. York M. J., May 20, 1911.)

"There are varieties of chronic tuberculosis of the cervical nodes in which the clinical features are not distinctive and the diagnosis usually is made after excision and histological examination. Among these are at least two types of so-called hyperplastic tuberculosis, one attended by extraordinary increase in the endothelial cells of the sinuses, the other by diffuse hyperplasia of lymphoid cells without the formation of recognizable tubercles.

"In the first type of hyperplastic tuberculosis the lymph nodes attain variable sizes, are painless, firm and movable, and do not tend to necrose. Hence, the condition does not offer any essential clinical variations from Hodgkin's disease, and indeed the two lesions are often confounded.

"On removal it is seen that the individual nodes are invested by a connective tissue capsule, while the cut surface is perfectly smooth, faintly yellowish or dead white in color—naked eye features which have prompted the somewhat homely designation of "potato lymph node.' Microscopical examination reveals characteristic changes, the most striking of which consists in widespread hyperplasia of the endothelial cells, and of almost complete disappearance of the lymphoid elements. Here and there, however, typical Langhans' giant cells occur, and at times, though rarely, definite tubercles may be seen. The tuberculous nature of the lesion may be further demonstrated by staining for tubercle-bacilli, or by injecting guinea pigs with freshly emulsified tissue.

"In the second type of hyperplastic tuberculosis the cellular increase is confined to the lymphoid elements

and is diffuse in distribution. There is seldom any attempt to reproduce lymph-follicles, the cords and sinuses are obliterated, and the normal architecture of the node is scarcely recognizable. Thus the histological changes do not differ essentially from those of lymphatic leuchæmia or of pseudoleuchæmia in the sense that Cohnheim described the latter disease (*vide infra*). To establish, therefore, the tuberculous nature of the process, resource must be had to other methods."

TUBERCULOSIS.

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Cysts and ascites.—Cysts of the thoracic duct may originate within the wall, or the wall may become dilated to form a sac with a small opening connecting it with the main duct. They may be anomalous or congenital, or they may be due to injury or disease, involve any portion of the duct, and vary in size from a small pea to several inches in diameter. They may rupture so that their contents escape into any portion of the mediastinal, pleural or pericardial cavity, one or all combined, or may rupture through the diaphragm from the pleural to occupy the abdominal cavity, such a case having come under my own observation.

Glands may also become cystic and remain so, or rupture their contents into any of these cavities. Such cysts also vary in size and their contents remain serous or become infected.

CYSTS.

Rust: Zwei Beobachtungen aus dem Wiener Allgemeinen Krankenhaus uber eine eigene Entartung der Hoden als Folge einer Varicositat der Lymphgefasse besonders der systerna chyli und des ductus thoracicus. Arch. f. med. Erfahr. Berl., xix, 731-789, 1815.
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Ascites.—Chyle has been found occasionally within the mediastinal space associated with injury, diseased or analomous conditions of the lymph-channels, and when present it may become absorbed if undisturbed and the opening in the duct closed, or it may be removed by artificial means, such as aspiration by trephine of the sternum or through the intercostal space, or by open drainage through an incision in the intercostal space, trephine or a cartilaginous flap. If by the open method the opened smaller lymph-channels may be ligated, when the ductus thoracicus is open, it may be repaired by suture or closed by ligature, and in either case the thoracic wall should be closed and drainage maintained indefinitely, tape or rubber tubing probably being the most appropriate means.

ASCITES.

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Cancer.—The importance of the lymphatics, especially in malignant growths of the thorax and its viscera, require them to be considered surgically, because without the removal of glands associated with cancerous growths a cure is supposed to be an impossibility. Is it possible for a malignant growth to exist without lymphatic involvement? If not, what proportion of glands and lymph channels are involved? Are they involved as groups? Can one gland in a group be involved without all of that group being involved? Can one group be affected without all groups being affected?

Carcinoma and lymphosarcoma are two of the most common forms of cancer found in the thoracic duct and lymph nodes. They occur both primarily and secondarily, more frequently, however, secondarily. The frequency of primary involvement, being difficult to determine, prompts this statement.

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CHAPTER XVI.

SURGERY OF THE PNEUMOGASTRIC NERVES (MOTOR-SENSORY.*)

THE PNEUMOGASTRIC NERVE.

Anatomy.—"The right pneumogastric nerve passes between the subclavian vein and the first portion of the subclavian artery, enters the chest through its superior opening, and descends in the superior mediastinum behind the right innominate vein on the right side of the trachea to the posterior mediastinum. Behind the bronchus it becomes broad and flat and supplies several branches to the right posterior pulmonary plexus. Thence the nerve descends as two cords upon the right side of the esophagus, where it gives off numerous branches which inosculate with similar branches from the left nerve.

"These branches of both pneumogastric ramify on the anterior and posterior surfaces of the esophagus and from the plexus gulæ, or esophageal plexus. Beyond this plexus the right pneumogastric nerve continues as a single cord on the posterior surface of the esophagus, entering the abdomen through the esophageal opening of the diaphragm. It is then distributed to the posterior surface of the stomach and supplies branches to the celiac, splenic, and left renal plexuses.

"*The left pneumogastric nerve* enters the chest at its superior opening between the left common carotid and the left subclavian arteries and behind the left innominate vein.

"*It descends in the superior mediastinum* between the left common carotid and the left subclavian arteries, and, bending backward, comes in front of the left side of the transverse portion of the arch of the aorta, and passes to the posterior surface of the lung

* An illustrated lecture delivered to students of the [illegible] Medical College, St. Louis, Mo., April 10, 1885.

of the left lung, where it becomes an occupant of the posterior mediastinum.

"From this point its course is similar to that of the right pneumogastric.

"It supplies branches to the left posterior pulmonary plexus; descends as two cords on the left side of the esophagus; assists in the formation of the esophageal plexus; then, as a single trunk, descends on the anterior surface of the esophagus, and passes through the esophageal opening of the diaphragm.

"It is distributed to the anterior surface of the stomach and supplies branches to the hepatic plexus.

"In the chest, in addition to those mentioned above, each nerve gives off branches to the anterior pulmonary plexus and the deep cardiac plexus, and the recurrent laryngeal nerve."—(Deaver.)

The vagi are often anomalous in diameter, points of bifurcation and position.

History.—Though the vagi have been described for several centuries, their function remained undetermined until a compartively recent date. Longet (1849) mentioned the "nature and veritable usages of the various anastomoses of the vagi," while Jacquart (1864) described their pulmonary distribution in ophidians; Langenbaker (1877) that of the vagi in domesticated animals, and Stowell (1881) that of the domesticated cat.

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SYMPTOMATOLOGY, DIAGNOSIS AND PATHOLOGY.

Symptoms coincident with disease and injury of the vagi are not altogether clearly defined. Many, no doubt, have been improperly ascribed, especially by the earlier investigators, whose opportunities were limited. Compression-paralysis, neuralgia, neuritis, hypertrophy, atrophy, trauma and neurosis, together with the various methods of producing them experimentally, have been the means of forming reasonable symptomatic conclusions. Schwarzenberg (1764) mentioned a rare form of spasmodic convulsions due to certain conditions of the vagi.

Symptoms of pressure of aneurysmal or other tumors upon the vagus and recurrent nerves are mani-

fested by laryngeal disturbances, as suggested by Johnson (1875).

Helm (1882) reported on anatomy and pathology of the nucleus of the vagi with reference to the theory of respiratory and cough-reflexes, development and regeneration, and Habershon (1885) on the influence of cold shock upon the vagi.

Neuralgia.—Neuralgia of the vagi was described as early as 1828 by Pinel, since which time but little has been said in favor of its existence, because of the uncertainty of ways and means for its determination. The sensory fibers which enter into its construction are, no doubt, responsible for more or less undetermined pain so often manifested in the thorax.

Pinel (1828) reported a case of neuralgia of the pneumogastric nerve, and Prus (1892) one in which he observed symptoms simulating hysteria.

Schupmann (1840) recorded a case of neuralgia of the vagus, while Lederer (1860) reported one similar in character.

Pressure.—Pressure of the neoplasms and anatomical irregularities, both congenital and acquired, upon the vagi, has been known to produce physiological disturbances of the organs which they control.

In the North American Archives of Medicine and Surgery, Sc. Balt. ii, 172, 175, 1835, is mentioned a case of asthma; aneurysm of the arch of the aorta; disease of the vagi, and phrenic nerves; large glandular tumors compressing them; hepatization of the lower part of both lungs and deaths from smallpox.

Herard (1846) reported a case of perforation of the bronchus and compression of the vagi due to a tumor.

Worthington (1855) records a death due to pressure of a tumor upon the vagus nerves, and Schwing (1857) one due to pressure from a stenosed foramen.

Sir Wm. Gull (1859) reported a case of death due to destructive changes of the lung from diseases in the mediastinum invading or compressing the pneumogastric nerves and pulmonary plexus.

Potain (1861) considered at length hypertrophy of the bronchial ganglion and its influence upon the vagi,

and Hittner (1865) stated that a tumor involving the vagus caused peripheral and reflex pain.

Stackler (1882) contributed an essay in which he claimed that epileptic convulsions were due to compression of the vagi; while Chapin (1907) reported a case of compression of the vagi, and Oppert (1907) one of death due to pressure of a tubercular cyst.

Neuritis.—Neuritis of the vagi is probably of vagrant occurrence. It may be primary or secondary; acute, sub-acute or chronic; localized or general, due to disease or injury.

Rosch (1837) and Weiss (1842) each wrote upon the subject of inflammation of the vagi. Browne (1896) and Mader (1898) each reported cases which they believed to be of this character. Perna (1904) refers to inflammation of the inferior laryngeal nerve.

Neuritis affecting the perineurium or sheath results more frequently with an infected wound than without it, but the nerve-fibrers may even then escape serious damage. If the infection extends to the endoneurium, the nerve-fibers will become more or less affected. Pathological exudate is always to be considered more or less seriously, especially in the parenchymatous form, for the disease originates in the nerve fibers.

Hypertrophy.—Cook (1837) reported his observations on the ganglionic enlargement of the vagus; the probable function of the ganglion; the position it occupies in the human subject, and in several of the lower animals.

Hypertrophy of the vagi or bronchial ganglia has been observed in both man and animal, and is probably due to injury and disease. It may be localized or general.

Neurosis.—Neurosis of the vagi was considered an independent disease by Blufus (1842), Sherman 1856), and Lederer (1866). Pupier considered its origin to be in the brain, and Torres (1877) wrote on functional disturbances due to neurosis of the vagi. Such conditions have been verified by more recent observers.

Traumatic Pressure.—Pressure from depressed fracture of ribs or cartilages and vertebrae has been proven to be effectual in causing functional disturb-

nerve of the vagi also benign bodies arising from within and without.

Bernard (1853) reports a remarkable case of asphyxia produced by traumatic compression of the vagi and sympathetics.

Pain.—Pain in the vagi is reported by Anderson (1874), who states that it was of a burning character in the fauces; that it was attributed to the vagus and it was relieved by atropin.

Cancer.—Secondary cancer of the vagus due to infection of the neck is reported by McCallum (1904). Primary neoplasms of any character are indeed rarely if ever found in the vagi. If so, they have not reached the ordinary literary channels, though Taylor (1905) reported having observed a calcareous deposit in the vagus.

Paralysis.—Paralysis does not always result from severing or even excising portions of one or both vagi, though it quite commonly occurs, probably depending upon the point of severance. The sympathetic dominates after severance.

Paralysis of the vagi was reported by Collier (1882), and Holdsworth and Hoffman (1907), also Stenhaus (1908).

Repair, Regeneration.—Mureau (1857) by experiments upon Albino rats, found that regeneration with complete restoration of function could be obtained after the vagi had been divided. His experiments were confirmed by Philogeaux during the same year.

New nerve elements grow centripetally from the proximal end, thus indicating that the ends of nerves must be united when completely severed. When not completely severed the time required for regeneration is six to eighteen months, each depending upon the distance of the injury from the peripheral endings of the nerve. Protopathic returns earlier than epicritic sensibility, the latter requiring two years. The area of the last sensibility is greater in the protopathic form. Divided nerves do not lose their capacity for the function of conducting impulses, therefore do not undergo complete degeneration.

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Surgery (experimental and applied).—The pneumogastric nerves may be lacerated or severed by injury or surgical operation, and thus require anastomosis by suture. The severance of one by external violence need not require immediate anastomosis, while the severance of both by external violence would result

in too rapid death to permit of successful anastomosis; if but one is divided by external violence there is ample time for anastomosis. If one or both are divided by surgical operation while the chest is open, they may be immediately united and perhaps the life of the patient thus be saved. Double vagotomy has been done in dogs without causing death.

Experiments upon the vagi are of ancient origin. They have been made principally to determine their physiological effects upon the organs which they supply, but those to determine their surgical possibilities are of more recent origin.

Injections of various medicaments, stretching, and the application of pressure by ligature, forceps or otherwise, together with internal administration of various drugs, have been selected methods to determine certain functional results.

Surgery—experimental and applied:

1. Compression.
2. Vagotomy.
3. Vagestomy.
4. Stretching.
5. Vagorrhaphy.
6. Electricity.
7. Miscellaneous.

Compression.—Compression, various ways—gauze, ligature, fingers, instruments.

Persistent pressure will partially or completely destroy nerve-function.

Compression of the vagi may be done artificially with gauze, ligature, instruments or foreign bodies, or by neoplasms, fractured vertebrae, ribs or cartilages.

History.—Compression of the vagus nerves, to determine its effect upon the respiratory and digestive tract, was done by Dupuy (1816 and 1821) and Mayer (1827), while Habershon (1864) illustrated the effects upon aneurysmal tumors after implication of the bronchus and the vagus nerves.

Navrotski (1870) studied the effects of blood pressure on the vagus nerves, and Waller (1870) compressed the vagus nerves to produce adynamia or anesthesia in surgical operations. He also compressed the

vagus nerve in the cure or relief of various nervous affections. P. Dix (1872), after removing a tumor from the inferior carotid triangle, noticed considerable functional disturbance of the vagi, and Johnson (1875) recognized laryngeal symptoms resulting from the pressure of a tumor upon the vagus and recurring nerves. Salamon (1880) reported suppurating bronchial pneumonia resulting from the pressure of the vagus due to aneurysm of the bronchio-cephalic.

Francois-Franck (1886) discussed at length the communication of Lafout upon the various effects of compressing the vagus.

Boix (1893) produced tachycardia by compressing the vagus nerve, Dubois noted the functional disturbances by compressing the vagus nerve, and Marklen (1893) compressed the vagus to produce systolic changes of the heart.

Walravens (1896) compressed the vagus nerves to determine its effect upon urinary secretion.

Vagotomy.—Vagotomy may be done by incision, ligature, cautery or laceration, such methods having been employed in both animal and man, at every point throughout its course.

History.—Ware (1828) performed vagotomy to determine its effects upon the heart and lungs.

Bouley (1852) made a section of the vagus to determine the powers of absorption of the stomach, and Boddart (1862) the effects upon the lungs after section of the vagus nerves.

Roddaert (1862) reported his experiments upon consecutive sections of the vagi for pulmonary lesions.

Krishaber (1869) reported his observations on the phenomena provoked by chloroform after section of the vagi, and Boddart (1877) some remarkable observations upon the results of simultaneous section of the vagi in the cervical region.

Francois-Franck (1879), after injuring a vagus nerve with a ligature and contusion, restored its function by electri-nervotomy.

Vaulair (1893) made successive divisions of the vagus without causing death, but Pavloff (1894) produced death of animals by section of the vagi. Mar-

tini (1894) made vagotomy and then sutured the ends together. Pavloff (1895) severed both vagus nerves of dogs to determine the results other than death. Herzen (1897) caused double vagotomy without death.

Cheskoff (1900) vagotomized dogs with respect to circulation, respiration, digestion and heart regulation, and Ribera (1901) sectioned the vagus for similar purposes.

Mercenghi (1901) reported his observations of the effects of bilateral vagotomy upon respiration. Niklaides (1901) demonstrated the general effects of vagotomy, while Crile (1902) studied the effects of severing and mechanically irritating the vagi.

Gomes (1903) made a double vagotomy, and Frouis and Paferski (1904) made an intra-thoracic section of the vagus through the abdominal cavity. Martini (1904) performed vagotomy upon dogs, and Lusckai (1905) anastomosed both for experimental purposes.

Starck (1904) did an intra-thoracic vagotomy, while Firori (1904) considered the surgical possibilities of the vagi.

Stewart (1905) made simultaneous section of both vagi above the origin of the recurrent laryngeal nerves, and Cannon (1906) studied the motor-activities of the alimentary canal after splanchic and vagus section. Cannis (1909) observed the alterations of the myocardium after vagotomy, and the same year reported a case of survival and regeneration of the vagus nerves after double vagotomy, and Jacquet one of accidental section of the vagus.

Cutting Both Phrenic Nerves in Tetanus.—Jehn reports from Sauerbruch's clinic at Zurich a case of extremely severe tetanus in a boy of eight who was suffocating from recurring spasms of the respiratory apparatus, each lasting three or four minutes with cyanosis and unconsciousness. The rigid thorax and spasm of the diaphragm rendered artificial respiration impossible. After the third spasm of the kind Sauerbruch severed the phrenic nerve on each side through an incision along the posterior margin of the sternocleidomastoid, under ether. The type of breathing altered at once and artificial respiration became pos-

sible. The boy had thirty-five severe convulsions afterward, but with oxygen, artificial respiration and a temporary gastrostomy he was tided along to final recovery. The boy shows no ill effects now, four months later; the diaphragm rises and falls mechanically with the breathing. Expectoration proceeds even better than under normal conditions.—Munchener Med. Woch., October 6, lxi, No. 40, pp. 2025-2056, 1914.

Vagestomy—History.—Segments of the pneumogastric nerve were first removed for experimental purposes by Cruveilhier (1831) and Henkel (1833). Since then many similar operations have been made upon both animal and man for various purposes. Claud Bernard (1849) produced paralysis of the esophagus by resecting the vagus without producing death, as did also Bieroliet (1857), while Kappeler (1864) extirpated about one-half inch of the vagus for laryngospasm. Wood (1874) produced suspension of the intestinal secretion and failure to produce purgation after section of the par vagum; and Vogel (1883) reported on the prognosis after vagus resection; while Arthud and Butte (1889) reported the results of their researches upon the effects produced upon the diaphragm by resection of the vagus. Ramvereda (1891) extirpated a vagus containing a sarcoma, Widmer (1893) resected the vagus nerve, and Giordano (1893) considered the lesions of the vagi that might become surgical, and Park (1895) determined the results of resection of the vagus and phrenic nerves.

Preisz (1898) removed the vagus recurrens nerves in a case of chorea laryngis, and Marenghi (1898) recorded his observations on nervotomy and nervectomy of the vagi with reference to the problems of regeneration of their peripheral fibers.

Kachkovski (1899) excised simultaneously the vagus nerves in the neck of dogs without destroying their lives. Mollard and Regard (1899) reported on the lesions of the heart muscles, and Cervera (1901) resected the vagus to determine the results upon the function of the heart and trigeminal nerves, and the result of consecutive resection of the vagi. Ladoue

(1900) communicated the phenomenon of chromatolysis resulting from resection of the vagi.

Cheshkoff (1902) observed the lives of dogs for a year and seven months after simultaneous excision of both vagus nerves.

Ruddel (1902) resected the vagus nerve, while Veaot (1907) reported resection of the pneumogastric nerve for a primary sarcoma.

Tuffier (1907) considered the proposition of resecting the vagi, while Broeckaert (1907) wrote upon its technique, and Murcell (1908) resected the right vagus nerve containing a malignant neoplasm. Deknoff (1909) resected the vagus nerve in man, and Dechonoro (1909) also resected the vagus nerve.

Stretching.—Stretching the vagus nerve in animals has been done for many years for physiological purposes, but it was not done in man until 1898, when Jaboulay did it to relieve certain intrathoracic pains.

Vagorrhaphy—History—Suturing may be necessary to unite the severed ends due to any cause. It can best be done with silk or catgut, when the chest is opened by intra-tracheal insufflation, or by means of the vacuum chamber. It may be immediately necessary when severed during a surgical operation of any character upon the thoracic viscera or when severed by injury. The severed ends of these nerves have been successfully sutured in animal experimentation, and in man.

Vagorrhaphy primary or secondary is employed for neurotomy or neurectomy due to accident or surgical trauma.

Primary, when the suture is applied immediately or soon after partial or complete severance.

Secondary, when employed for anastomic purposes after considerable time has elapsed.

Phillipaux and Vulpian (1863) were the first to demonstrate by animal experimentation that nerves can be united by suture without loss of function. This means of union is best accomplished with a fine needle and silk suture, because of its superior strength and small size.

The necessarily increased size of the sutures and the

needles required to carry them through the nerve would render the use of absorbable materials such as catgut and kangaroo-tendon of equal strength and durability exceedingly objectionable because of the resulting trauma.

With normal nerve-tissue a needle, without cutting the edges, may easily be inserted, but with the presence of cicatricial nerve tissue such a needle is necessary, especially with dense neuromata. With secondary suture, function is usually incomplete, because of atrophy. The nerve may have become permanently shortened, thereby causing great permanent loss of function.

If electrical stimulation by constant current is effective, motive power may be benefited. Sherren believes that the length of time of separation of the ends is of less importance than infection of the wound.

Wertheimer (1907) anastomosed a vagus nerve in the thorax of the human being.

Miscellaneous Surgery.—In this division many interesting data pertaining to the general surgical possibilities of the vagi are found.

History.—Ware (1828) imposed trauma upon the vagus nerves to determine its effect upon the lungs and stomach, and Laffont (1836) injected hydrate of chloral and chloroform into dogs intravenously to determine the effects upon the heart and vagus nerves.

Fearn (1847) reported a case of gunshot wound of the internal carotid artery and division of the vagus. He ligated the artery, but did nothing to unite the ends of the nerve. Recovery. Blake (1865) reported a wound of the neck; apparent recovery, sudden death.

Boullard (1891) records a case of mortal injury to the vagus nerve. Djelicoff (1901) contributed to the study of accidents to the heart and vagi; Giordano (1893), on surgical lesions of the vagi; and Langley (1897) made a series of experiments about the junction of the vagus nerve with the cells of the superior cervical ganglion, and Osipoff (1898) in the region of the origin of the central or the tenth pair of cranial nerves.

Powers (1903) removed a heavy silk ligature that

had been applied to the right common carotid artery and which unfortunately had included its corresponding vagus nerve for more than one year. He also reported clinical symptoms before and after removal.

The after-care for sutured vagi should, as a rule, when through the neck, be drainage for twenty-four hours when not primarily infected, and continuously when infected, primarily or secondarily. Quietude, liquid diet and recumbency should always be insisted upon.

Soiled dressings should be changed frequently, but irrigation is seldom indicated.

Surgery.—Ways of approaching the nerve:

1. Transcervical.
2. Transthoracic.
3. Trans-abdomino-diaphragmatico-thoracic.

(1) *Transcervical* (Technique). Vagotomy, vagectomy, stretching, vagorrhaphy and the direct application of the needle for electrolysis, or the injection of medicaments are done in an incision through the skin and sterno-mastoid muscle at the level of the cricoid cartilage. The deep jugular is turned aside and the nerve separated from the common carotid artery and sheath. Great care should be exercised to prevent injury to the vein and artery.

(2) *Transthoracic* (Technique). After severing the ribs at their sternal junction or removing the sternum, the vagi may be seen in the superior mediastinum behind the right innominate vein on the right side of the trachea. (See anatomy.)

(3) *Trans-abdomino-diaphragmatico-thoracic.* The upper abdominal wall having been opened, the diaphragm may be incised one inch to the left of the gastro-esophageal junction, when the vagi may be observed with but little difficulty.

SURGERY—EXPERIMENTAL AND APPLIED.

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CHAPTER XVII.

DIAPHRAGM.*

DIAPHRAGMOTOMY—DIAPHRAGMECTOMY —DIAPHRAGMORRHAPHY.

(See Ricketts, Surgery of the Prostate, Pancreas, Diaphragm, Spleen, Thyroid Gland, and Hydrocephalus, pp. 73-91, 1904.)

The diaphragm separates the thoracic and abdominal cavities, so that any of its surgical conditions must necessarily concern both, probably more frequently that of the abdomen. However, it must be included as a part of the thoracic cavity. The diaphragm is absent in amphibians and saurians, so that their pleural cavities are lined with peritoneum. Mammals have a diaphragm, and while it is more highly developed in man, its formation is not understood. As an anomaly in man it is occasionally absent, and sometimes the openings through which the esophagus, vena cava and aorta pass, vary in size, shape and location. Owing to areolar tissue, pleura upon the thoracic, and peritoneum on the abdominal side, there is a deficiency in in the fibres of the diaphragm about the ensiform appendage and cartilages of the adjoining ribs.

Ectopia of the diaphragm has been reported by John (1867), and organs are usually displaced when a part or all of the diaphragm is deficient.

Surgery of the diaphragm is exceedingly rare, and confined principally to incisions and suture, either of which may be accompanied by an incision through the abdominal, or preferably and most frequently the thoracic wall, after one or more ribs have been removed. Drainage is always necessary if the wound is infected at the time or subsequently to the operation.

Dr. John Young Brown has probably had as much

* An illustrated lecture delivered to the students of the American Medical College, St. Louis, Mo., May 12, 1911.

experience with surgery of the diaphragm as any other man. Cysts of the diaphragm containing blood, pus or serum, may be due to bacteria or parasites, usually in the thicker portions of the diaphragm, and may rupture to escape through the psoas muscle. Some of these cases perplex the diagnostician in making a differential diagnosis between diaphragmatic and tubercular disease of the vertebræ.

Neoplasms and cysts of the diaphragm have not been frequently subjected to surgery. However, gunshot, stab and laceration wounds have been made to yield their disastrous effects to surgical skill.

Diaphragmotomy is done through the abdominal or thoracic cavity, with much difficulty, especially in remote parts, but in the absence of infection the dangers should not be great.

Indications for Diaphragmotomy: Cysts, neoplasms, hernia, abscess, cardiac manipulation.

Cysts of this muscle may be of many varieties, parasitic or otherwise. They may be opened anteriorly or posteriorly through the thoracic cavity, with or without drainage, unless infected, and they may also be opened through an incision in the abdominal wall with or without drainage.

Neoplasms, malignant or non-malignant, may develop within the diaphragm. Usually only those non-malignant are amenable to excision, through an incision in the abdominal or thoracic wall, with or without drainage.

Those benign are tubercular, angiomata, lipomata, fibromata or chondromata, extending from its periosteal attachments, and the malignant are tumors, sarcomata and carcinomata. Ossification of the diaphragm has been found in several cases.

Hernia, congenital or acquired, of the lung, through the diaphragm, reducible or irreducible, is rare, while that of the stomach or intestines, or both, is more frequent. Of several hundred reported, there were but one or two on the right side. Its rare occurrence on the right side is due to the relation of the liver to the diaphragm. Abdominal visceral hernia of the diaphragm is usually operated on from below, because

its reduction is more easily accomplished in this way. The presence of adhesions or gangrene of the intestinal tract render this the safer method.

Cornell (1825) reports a case in which "all of the intestines" (?) escaped through the diaphragm into the right thoracic cavity. Hurst (1827) recorded a case in which the stomach escaped through a rent in the diaphragm. Various degrees of hernia may exist indefinitely without being detected or causing serious trouble.

Hernia of the Diaphragm.—Traumatic and acquired. T. C. Little-Jones, Liverpool, Liverpool Medico-Chirurgical Journal, July, 1909.—"The author reports two interesting cases. The first was that of a young man who fell down a flight of stairs and shattered a picture glass. He sustained a wound about two and one-half inches long in his seventh left intercostal space, through which a small piece of omentum was protruding. The author removed the eighth rib, cleaned out the pleural cavity of a large amount of blood and glass, and found a rent one and one-half inches in length in the diaphragm, about half an inch from the pericardium, through which omentum was protruding. The omentum was ligated and removed, and the rent in the diaphragm was sutured. Despite a rather severe attack of pneumonia the patient recovered, and is today perfectly well. The second case occurred in a child of eight, who gave a history of repeated attacks of colic, consequent upon a fall which had occurred eight months before. An attack of obstruction intervening, the patient was operated upon and it was found that the omentum and parts of the transverse and descending colon had passed into the left pleural cavity through a hole the size of a shilling. Great difficulty was met with in attempting to reduce the contents, but this was finally accomplished when the negative pressure in the pleural cavity was released by puncturing the diaphragm with a probe-director. Nevertheless, a portion of the omentum was found densely adherent, and the author contented himself with closing the opening in the diaphragm with the prolapsed omentum.

The patient seemed to do well for two days, and then died from causes not discoverable at the autopsy."

A Case of Diaphragmatic Hernia—A. Bamberger, Chicago.—He reports this case not only because of the rarity of diaphragmatic hernia, but also because of the abstruse and puzzling symptoms it presented.

"Past history: The patient, W. W., a negro butler, aged 23, had had the diseases of childhood, gonorrhea several times, but denied syphilis. He used alcohol and tobacco in moderation, but denied coming in contact with lead in any form. He had never had a similar illness, and was well up to the onset of the present trouble. Ten years previously he had been stabbed in the left seventh intercostal space just lateral to the anterior axillary line. The cut was about two inches long, through which a mass looking like fat (as he described it) protruded. The wound was sutured under general anesthesia and an uneventful recovery followed.

"Present trouble: About 12:30 A. M., July 24, 1910, he entered my service at the Cook County Hospital. He gave the following history: Five days previously a sharp pain started on the left side of the abdomen, about two and one-half inches below the costal arch, which grew so severe that he was unable to sleep that night. He vomited, but had no chills or fever. Bowels had been constipated since the onset of the pain, and resisted all cathartics and flushings that a physician had administered. The pain in the left side of the abdomen, which had radiated to the epigastrium, and the vomiting and constipation, persisted until entrance to the hospital. On the day before admittance to the hospital he vomited a brownish material, which, as he expressed it, looked like manure.

"Examination: The patient walked into the ward, but apparently had some pain. He was well nourished. There was no cynosis or dyspnea; temperature, 99.2 F., per month; pulse, 64; respirations, 24, on admittance. The pupils were equal and reacted to light and accommodation. There was no rigidity of the neck and no lead-line along the gums. The throat was negative. The lungs expanded equally on both sides.

Dullness began posteriorly one hand's breadth below the angle of the scapula. There were no abnormal palpatory, percussion or auscultory findings. The pulse was full, slow and regular. The heart was on the left side of the chest, not enlarged, and showed no murmurs. The abdomen was not distended, and peristalic waves could not be seen or auscultated. There was tympany all over. Some tenderness and rigidity were present over the entire abdomen, but especially in the region of the appendix. In the right anterior lumbar region there was an ovoid tumor mass, tympanitic and tender, but not movable. Liver and spleen were not palpable. The genitalia were negative. There was no stricture, prolapse or tumor of the rectum. Knee-jerks were present; no Babinski or ankle-clonus. The urine was amber, clear; specific gravity, 1.038; no albumen, no sugar, no casts; leukocytes, 6,250.

"Course: Repeated colonic flushings and '1-2-3' enemas were given with no results, and twelve hours after admittance the patient was practically in the same condition as when he entered; so the diagnosis of intestinal obstruction was made, the exact type of which was not known, and an operation decided on. Because of the good condition of the patient and the lack of marked abdominal symptoms, some physicians who saw the case believed the condition to be an acute catarrhal appendicitis with paralytic ileus.

"Operation: An incision was made in the mid-line of the abdomen. The appendix was normal, but the cecum and ascending colon were markedly distended. The small intestine was run through, but no obstruction was found. The transverse colon was distended, but the colon below the splenic flexure was collapsed. In the lower border of the diaphragm, just to the left of the median line, was a hole large enough to admit the finger-tip, in which a knuckle of the descending colon was bound down so firmly by adhesions that it was deemed safer to let the obstruction alone and do a lateral anastomosis between the portion of the colon proximal to the obstruction and the sigmoid. This was done in the usual way. A drainage-tube was inserted

in the left side of the abdomen; the peritoneum and fascia were closed with continuous catgut, and the skin was sutured with interrupted silkworm gut.

"Postoperative history: For four days after the operation the patient had a temperature of 98.8 to 102 F. per rectum, and on July 30, five days after the operation, he had a bowel movement. He then made an uneventful recovery.

"The points to be considered in this case are:

"1. The long time (ten years) elapsing between the time of injury to the diaphragm and the occurrence of the hernia.

"2. The relatively few symptoms of intestinal obstruction and its close resemblance to appendicitis; also the good general condition of the patient, which is not usually seen in intestinal obstruction; and the fact that the patient recovered after being ill six days with an intestinal obstruction, in which condition the mortality is very high after forty-eight hours' duration."

Intercostal diaphragmatic hernia is considered at great length by Gerster, who tabulates thirteen such cases, including one of his own. The first case was reported by Cloquet (1819).

HERNIA.

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Subphrenic abscess.—Abscess of the diaphragm may be primary or secondary, result from liver or pulmonary abscess or infections of the pleura, peritoneum, kidney, appendix, or any bacteria that may produce infection of cysts of any character such as echinococcic and other cysts. Such cavities may be opened and drained through an anterior or posterior abdominal incision.

History (Roth). "For a complete history of the literature of subphrenic abscess, the writer begs to refer to Piquand's very excellent contribution, which is based upon all the cases reported in literature up to a very recent date. He divides the history of subphrenic abscess into three periods, the first one extending from the beginning of the eighteenth century until 1845. During this period are found scattered reports of subphrenic abscesses discovered on autopsy.

"*The next period* is the one during which a diagnosis was made during life; this was first done by Barlow, who wrote upon the differential diagnosis of subphrenic abscess and purulent pleuritic exudates. The next report was made thirty-two years later by

Eisenlohr. In 1879 appeared the classical paper by Leyden, in which a very clear account is given of the conditions designated by him as pyopneumothorax subphrenicus. This was followed by a goodly number of other publications.

"*The third, or the period of surgical intervention,* begins in 1890, with the memoire of Debove et Redmond, describing a case in which a diagnosis was made in advance of incision and drainage. In 1891 Novack published a work on the pathological diagnosis and treatment of subphrenic abscess. In 1893 Mason reported two new cases and reviewed previous works on the subject; this probably being the first American report. In 1894 appeared Maydl's excellent monograph, which justly merits a prominent place in the history of our subject. He reported a number of personal observations, and collected from the literature 179 cases which served as the basis of a very remarkable anatomical and clinical study from a surgical standpoint. During the same year appeared a monograph by Langenbuch. In 1895 Sachs published an article based upon a study of forty-one cases of subphrenic abscess of appendiceal and perirenal origin. In 1896 Beck read a paper advocating the transpleurodiaphragmatic incision of subphrenic abscess, a procedure advocated also by Trojanow, Lauenstein, and in 1897 by Finkelstein, whose thesis was the most complete work published up to that time, as it was based upon 252 collected observations. In 1900 Fenwick published a paper upon subphrenic abscess of gastric origin, and Weber reported nine cases of appendiceal origin from Sonnenburg's clinic. In 1901 Elsberg reported two cases, secondary to appendicitis, and collected seventy-one published up to that year, basing his analysis upon seventy-three cases. In 1902 Lejars reported a number of cases and gave minute therapeutic indications and routes of access in each variety. In 1905 Perutz studied 208 cases which he was able to collect from the literature since the publication of Maydl's monograph. During this same period appeared Gruneisen's report of sixty cases operated upon by Korte in ten years. In 1908 Eisen-

drath added thirty-three cases of appendicular origin, including five of his own, to those studied by Elsberg. A very interesting contribution upon the subject is from the pen of Barnard. The next publication of importance, from which the writer will freely quote, is the one by Piquand referred to previously. It is based upon the analysis of 890 cases collected from the literature, the majority of which have been reported during the last ten years.

"*Etiology* (Roth).—A subphrenic abscess may occur at any age and in either sex, and is almost always secondary to a perforation or inflammation of some intra-abdominal organ. The largest number are secondary to perforations of gastric or duodenal ulcers. Appendicitis is the next frequent cause.

"It is difficult to describe the course of the infection in this case. It may have resulted from the diffuse peritonitis which became localized in the left subphrenic space. In relating the history to Dr. Francis Huber he suggested the possibility of a splenic infarct which terminated in the abscess and which was originally due to the appendiceal infection. The sudden onset of the chills, with the marked intermissions in the temperature a few days before the operation, would lead one to assume that such a course was possible. The most important channels by which infection of the subphrenic space occurs are the lymphatic and blood vessels, the subperitoneal cellular tissue, and the peritoneum. Elsberg states that a subphrenic abscess secondary to appendicitis occurs in the following three ways:

"1. As a localization in the right or left subphrenic region of a general systemic infection—the infectious agents being carried to the subphrenic region by the blood current.

"2. As a localized abscess formation in the right or left subphrenic region of a general purulent peritonitis with foci of suppuration in various parts of the abdominal cavity. This variety is infrequent, as the patients generally die before encapsulation of the abscess can occur.

"3. As a local process by direct extension, or through

the lymph channels from disease in or around the vermiform appendix. This is the most frequent variety.

"In a number of cases the left-sided subphrenic abscess was undoubtedly a part of a general peritonitis, while in others the infection spread from the pelvis along the peritoneal surface. Most of the abscesses secondary to diseases of the uterus and appendages resulted from infection by way of the blood; a few were the result of a general peritonitis which localized in the pelvis and subphrenic space.

"*The abscess* may occupy only a small part of the subphrenic space. It may contain pus, or pus and gas, varying in amount and kind. The pus is usually very fetid, and if secondary to disease of the liver or bile tract is brown or chocolate colored; it may contain blood-clots, liver-cells, echinococcus-cysts, or even biliary calculi. The pus, in cases secondary to appendicitis, is usually fetid, thick, and may contain sloughs. In those due to stomach or duodenal perforation it may be foul and sour, and may be mixed with stomach contents. In tubercular cases the pus is usually odorless and cheesy. The gas is derived either from gas-forming bacteria or from some hollow viscus; in case of perforation into the lung it may be of pulmonary origin. Gas was present in more than twenty-five per cent. of the cases collected by Piquand. Various bacteria have been found in the pus, but the bacillus coli communis, streptococcus and staphylococcus are the most important.

"*Symptoms* (Roth).—The onset of a subphrenic abscess may be either acute or more insidious. In some cases the symptoms develop very slowly. Following an attack of abdominal pain suggestive of a subacute perforation of a gastric or duodenal ulcer, there develops pain in the upper part of the abdomen with distension and a rapid pulse. The temperature remains high, or, having been normal, it rises again and runs a remittent or intermittent course. The rise in the temperature may be preceded by a chill, vomiting, or nausea. Or, several days after an operation for a perforating gastric or duodenal ulcer, while the patient is apparently improving and the wound is

healing, the temperature and pulse begin to rise, and there is loss of weight and strength, with nausea and anorexia. There may be pain in the region of the shoulder. In cases secondary to lesions of the liver and biliary passages there may be a history of cholelithiasis, hepatitis, or cholangitis, and the skin may have an icteric hue. In cases secondary to a pancreatic lesion the symptoms are very acute, and resemble those of an acute perforative peritonitis of the upper abdomen.

"Speaking of subphrenic abscess secondary to appendicitis, Eisendrath distinguishes three modes of onset. In cases with an acute onset the symptoms of subphrenic abscess appear with the onset of appendicitis or a few days after. The temperature remains high, and is associated with symptoms of sepsis. There may or may not be pain in the right hypochondrium. In the subacute variety, about from eight to twenty-one days after operation, the temperature rises again and remains high or becomes remittent in type. Emaciation and weakness become very marked; anemia, anorexia, a rapid pulse-rate, and all signs of sepsis are very evident. In some cases the symptoms appear months after an operation for, or a diagnosis of, appendicitis. Symptoms of a chronic sepsis develop, which can only be attributed to some obscure focus.

"Associated with a high temperature and a rapid pulse-rate, there is hyperleucocytosis. Rapid loss of weight and strength, with a high temperature, may be the only symptoms present. Pain may be absent throughout the illness; if present, it varies in intensity, character and location, and is usually in the hypochondriac or epigastric region. In the retroperitoneal variety it is most marked in the lumbar region. With the onset of pleuritic complications there is pain in the side of the chest, dyspnea and cough, which may be preceded by a chill and followed by expectoration. When the abscess ruptures into the lung there is a marked cough with expectoration of large quantities of fetid pus, which may be bile-stained and at times contains echinococcus-cysts or liver-cells. Sudden ruptures of the abscess into the free pleura is fortun-

ately very rare, but when it does occur is quickly followed by marked dyspnea, collapse, and death. The onset of pericardial complications is marked by sudden precordial pain and other cardinal symptoms of pericarditis. Rupture into the general peritoneum is followed by the clinical picture of a general peritonitis.

"*Physical signs* (Roth).—The diagnosis depends, at times, upon physical signs which vary according to the presence or absence of gas in the abscess, and whether or not there are thoracic complications present. Physical signs may not develop until very late, or, with small abscesses, may be entirely wanting. The presence of pleuritic exudates or pulmonary complications makes a diagnosis at times very difficult. With an abscess low down or superficial there may be bulging and rigidity in the epigastric or hypochondriac regions. If the abscess is superficial there may be localized edema of the skin and dilatation of the cutaneous veins. Redness of the skin is extremely rare. Tenderness may be present over the most prominent part of the abscess, but is most likely to be found with a retroperitoneal abscess in which there may also be bulging in the lumbar region. Rigidity and prominence of the costal margins and bulging of the intercostal spaces, with local edema, may be present with a large subphrenic abscess. If a large amount of pus is present, the liver is markedly displaced downward. In cases without the presence of gas there is an area of dullness or flatness in or about the mid-axillary line, which is continuous with liver dullness and has a convex upper border. If the abscess is on the left side the area of dullness is in the lower part of the chest or in the epigastric region. If the abscess contains gas, and the patient is examined in the sitting posture, there is an area of tympany above the area of dullness. Above the tympanitic area there are normal resonance and vesicular breath-sounds. The lowest of the three zones is flat and is due to the presence of pus. In this area breath sounds and vocal fremitus is usually absent. If the abscess is large, succussion sound and the coin phenomenon might be demonstrated. The presence of a pleuritic exudate alters the above signs and

there are four different zones. The uppermost corresponds to normal lung, the next is a zone of flatness, due to the fluid in the pleura. Then comes an area of tympany corresponding to the gas in the abscess, and the lowest is a zone of flatness due to the presence of pus. The upper level of dullness of a large pleuritic effusion curves downward or is horizontal. The presence of a large quantity of gas might suggest a pyopneumothorax. But after all, the diagnosis in all cases must be verified by the examination of the chest with an exploring needle of fair size and good length. As a rule, the most sensitive part of the dull area is selected for the introduction of the needle; repeated introduction may be necessary, for the pus is often thick. In fact, this procedure is at times the only means by which we can arrive at a positive diagnosis; but even this may fail if the abscess be small, as in case iii, in which the entire hepatic area was repeatedly punctured without obtaining pus. Again the needle may withdraw only a small quantity of serum from a pleurisy complicating a small abscess, as happened in the above case. If the pus in a complicating empyema is of the same character as that in the abscess, exploratory puncture may not be conclusive. Several consecutive punctures may reveal fluid of different character. If the aspired fluid is fetid, or if gas escapes with it, it will point to a subphrenic abscess, especially if aspiration at a higher level shows serum or pus of a different character. Exploratory puncture in the presence of pus is looked upon by some surgeons as a dangerous procedure; therefore, if pus is aspirated the puncture should be followed by immediate operation to prevent the development of a phlegmon from leakage of pus along the needle track.

"*Differential diagnosis* (Roth).—In the diagnosis of subphrenic abscess a history of preceding intra-abdominal or pelvic lesions is of paramount importance. In the absence of such a history a diagnosis is very difficult. If the patient is seen in an advanced stage of the disease, when a painful bulging area is found in the epigastric, hypochondriac, or lumbar regions, the diagnosis is readily made. But the diag-

nosis should be made as early as possible and before thoracic or any other complications have developed. All means of diagnosis should be exhausted, including the X-rays, which might demonstrate a marked elevation of the paralyzed diaphragm. The most important conditions, from which a subphrenic abscess must be differentiated, are pleuritic exudates, which so frequently complicate the disease. The history of a preceding pneumonia favors pleurisy, empyema, abscess of the lung or pyopneumothorax rather than a subphrenic abscess. The presence of gas produces three different zones on percussion and readily suggests subphrenic abscess with a complicating pleuritic exudate. Aspiration of clear serum from a patient who is septic points rather to subphrenic abscess than to pleurisy with effusion. If a complicating empyema contains fetid pus, only an operation may determine the presence of the subphrenic abscess. The presence in the aspirated pus of bile, contents of the alimentary canal, liver cells, echinococci, favors a diagnosis of subphrenic abscess. The presence of the colon bacillus is also suggestive. A subphrenic abscess situated low down in the anterior part of the chest may simulate abscess of the liver, hydatids or cholecystitis.

"*Complications* (Roth).—The complications of subphrenic abscess result from hematogenous infection or from the extension of inflammation in the retroperitoneal or retropleural tissues. They are mainly thoracic, because of the lesser resistance of the pleura and pericardium, and probably also on account of the direction of the lymph stream. Pleuritic complications occurred in twenty-two per cent. of the cases collected by Piquand. Perforation of the diaphragm results from a long continued or virulent infection. The pleuritic exudate may be serous, serofibrinous, or purulent, it may be encapsulated or not, and occasionally it is bilateral. Of 191 cases secondary to appendicitis, thirty per cent. had a pleuritic involvement. Rupture of the abscess into the free pleura is fortunately rare. Usually the pulmonary and diaphragmatic pleura are adherent, and if perforation of the diaphragm does occur, the abscess ruptures directly into the lung,

causing pneumonia, abscess, or gangrene, or the pus may be evacuated by way of the bronchi. Pericarditis with serous or purulent exudate may occur with or without perforation of the abscess. Occasionally a subphrenic abscess ruptures into the peritoneal cavity or into some part of the digestive tract. Perforation of the skin has been extremely rare.

"*Conclusions* (Roth):

1. "*A subphrenic abscess* is, in a great majority of cases, secondary to a perforation or inflammation of some intra-abdominal organ; occasionally it results from injuries of the thorax or upper abdomen, and very rarely from a primary infection of the subphrenic space.

2. "*The abscess may be extra-peritoneal,* but the majority are intra-peritoneal. More than half of the subphrenic abscesses, secondary to appendicitis, are intra-peritoneal.

3. "*A subphrenic abscess*, secondary to perforation of a gastric ulcer, usually occurs on the left side of the suspensory ligament, while an abscess secondary to lesions of the liver or appendix is usually on the right side.

4. "The most important routes by which infection spreads to the subphrenic space are the lymphatic and blood-vessels, the subperitoneal tissue and the peritoneum.

5. "*Gas* is found in about twenty-five per cent. of the cases, and of the bacteria present in the pus the bacillus coli communis, the streptococcus and staphylococcus are the most important.

6. "*The complications* of subphrenic abscess are principally thoracic, namely, pleurisy with effusion, empyema, pneumonia, abscess of the lung, and pericarditis.

7. "*The onset* of subphrenic abscess may be either acute or insidious. Rapid loss of weight and strength with a high temperature, remittent or intermittent in character, may be the only symptoms present.

8. "*Physical signs* develop late and vary according to the presence or absence of gas with the pus. These

are at times very characteristic and may enable one to make a correct diagnosis.

9. *"Exploratory puncture* of the chest is of the utmost importance. It may be the only means by which a diagnosis can be made before operation.

10. *"In making a diagnosis* of subphrenic abscess, a history of a preceding intra-abdominal or pelvic disease is very valuable. If all other diagnostic means fail, exploratory incision should be resorted to.

11. *"Most patients* who are not operated upon die from sepsis or sudden perforation into the pleura, pericardium or peritoneum. The majority can be reduced only by early diagnosis and appropriate treatment.

12. *"The proper treatment* is by incision and drainage, the site of the incision depending upon the location of the abscess. If the abscess is low down in the epigastric or hypochondriac regions it is most readily reached through an incision in the median line or one below and parallel with the costal margin. Retroperitoneal abscesses can be opened through a lumbar incision. An abscess higher up in the chest is best treated by transpleurodiaphragmatic thoracotomy, or, better still, by Elsberg's subpleurodiaphragmatic thoracotomy. Occasionally a combination of these methods is necessary."

Incisions through the diaphragm are sometimes made to permit the heart to be grasped by the hand through the abdominal cavity for the purpose of cardiac stimulation. If successful, such wounds should be closed by silk or linen suture. (See Ricketts' Cardiac Stimulation by Digital Manipulation, Trans. Surg. Sect. Amer. Med. Association, pp. 504-535, 1906.)

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Diaphragmectomy.

The complete and successful removal of the diaphragm (while possible in man), has not been done, and probably will never be necessary. Its partial removal, however, is demanded when the removal of certain forms of neoplasms and gangrenous tissue is necessary, because it has been demonstrated that gangrene can be dealt with successfully. Friedrick records such a case in which he removed 160 centimeters of the diaphragm overlying the liver, with recovery.

In the absence of infection, drainage will not be necessary; when infected, drainage should be ample through both the thoracic and peritoneal cavities.

Diaphragmorrhaphy.

Diaphragmorrhaphy is done for incisions, punctures, lacerations and ruptures, accidental or intentional. It is more easily accomplished through an incision in the thoracic wall, though it may be done through one in the abdominal wall, depending upon the position of the rent. Drainage is probably necessary in the majority of cases, and oftener through the thoracic cavity.

Indications for diaphragmorrhaphy—incisions, lacerations, punctures and rupture.

Incisions for any purpose may or may not require suture, depending upon their size, location and purpose. infection of the pleural cavity.

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Lacerations are usually due to injury, short, long, irregular or linear in shape, and extend in any direction. They usually result from falling aloft, upon the buttocks, causing the abdominal viscera and lungs to exert their force in all directions; but they may, however, result from force applied in any direction upon the chest, fracture of ribs or cartilages, or pathological lesions.

Punctures may be smooth or irregular, single or multiple, aseptic or septic, or simple or complicated, and in any part of the muscle. They may or may not require suture, depending upon their extent and location. They may be produced by a sharp instrument or knife, or as the result of a gunshot wound. A knife injury usually bleeds more freely because of the sharp edges it produces.

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Stab wounds.—Magula reports his experience with operative treatment in sixty-one cases of stab-wounds

of the diaphragm at St. Petersburg. He has been able to find only 129 similar cases on record. Only twenty-five of his cases were without concomitant injury of other internal organs. The wound in the diaphragm was not diagnosed in 41 per cent. of the cases; in 9.7 per cent. the stab had been received in the fourth and fifth interspace. The danger of diaphragmatic hernia is so great, as also the possibility of unsuspected injury of other organs, that expectant treatment is contra-indicated. In case it proves impossible to suture the wound in the diaphragm, the lips of the wound may be sutured to the costal pleura as Frey has suggested. This prevents hernia and also danger of secondary infection of the pleural cavity.

STAB WOUNDS.

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Pravdolyuboff, V. V.: Wounds of the diaphragm. Khirurgia, Mosk., xxiii, 405-417, 1908.

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Ruptures may be due to injury or disease, and of little or much consequence. Usually serious, because of protrusion of abdominal or thoracic viscera. They may occur while the patient is in recumbent position from some debilitating condition for several months, or result from quick or violent motion. No doubt some of the small ruptures will repair themselves, and

the propriety of suturing all ruptures may be questioned. However, the patient should be given the benefit of the doubt, with exploration in all cases.

The post-operative treatment of the various operations upon the diaphragm is the same. Incisions and suturing for any cause may be done through the pleural or peritoneal cavity, with or without drainage, unless there is primary or secondary infection. Then drainage should be given exit at the lowest point for gravity. When the pleural cavity is opened sometimes gauze packing may accomplish this through the primary opening without the secondary opening.

Dressings should not be changed for several days, but if septic they should be removed daily. The recumbent position should be maintained for several days, and shallow respiration practiced, that the diaphragm may not be forced downward; coughing, sneezing, vomiting, and sudden change of body position should not occur for this reason.

RUPTURE.

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CHAPTER XVIII.

SURGERY OF THE MEDIASTINUM OTHER THAN FOR INJURY AND DISEASE OF THE CARDIOVASCULAR SYSTEM.*

Mediastinal, next to cardio-aortic surgery, is the most recent of any applied to the thorax and its viscera. This has been due to pneumothorax resulting from exposing the space directly or indirectly to atmospheric pressure, but now that ways and means have been devised to overcome this condition, any one or all of its four divisions may be exposed at the same time with comparative safety.

The cavity being formed by the soft structures of the neck above, the diaphragm below, sternum in front, vertebræ behind, and visceral pleuræ and pericardium laterally, together with the cardio-aortic system, esophagus, pneumogastric nerves, superior vena cava, thoracic duct, thymus and bronchial glands contained within it, render it a most frequent locality for disease and injury.

The relations of the spaces, in the absence of injury or disease, are not constant, because they are many times embryologically defective. With all forms of neoplasms the relations are more or less varied, while the presence of fluids, such as pus, serum, blood and chyle, only temporarily change the relations. This is demonstrated by their return to normal after their withdrawal.

Neoplasms, however, possess adhesions which may cause the space to become temporarily or permanently obliterated. Fluids, foreign bodies or neoplasms, may form within or enter from without the space and remain there, or disappear into other cavities or tissues,

*Read before the Western Surgical and Gynecological Association, Chicago, December 19-20, 1910.

or they may make their appearance externally, or in many instances disappear altogether by absorption.

Hare's (1888) Prize Essay must be the basis for future reckoning with injury and diseases of this locality. That which is appended represents the observations upon these conditions since then. There is no disposition to detract from the value or sentiment of his work, except possibly to speak more encouragingly upon their surgical aspects, now that ways and means have been devised that were not known at that time. With this in view, the subject in its generality will remain at rest for the present, the ultimate object being to make the two a resume of the subject as complete as possible up to the date of its publication, which will appear within a few months. The most conspicuous features of this subject are found in diagnostic and surgical measures, the first unmeasurably due to radiography, and the second to intra-tracheal insufflation.

About fifty per cent of all injuries and pathologic conditions of the mediastinum were found by Hare to be within its anterior portion. This was especially true with 134 carcinomata, 98 sarcomata, 115 abscesses, 11 dermoid cysts, 6 hematomata, 7 fibromata, 8 hydatids, 21 lymphomata and lymphadenomata, and 16 cases of mediastinitis (non-suppurative): total, 416 cases.

The posterior portion came next in order, while the middle and superior portions were very much less frequently attacked and about equally in number.

Those conditions of less frequency, according to Hare, are as follows:

Miscellaneous, 104; stated, 84; not stated, 56.

Twelve foreign bodies, ten gunshot wounds, eight cases of tubercular disease, three lipomata, three echondromata, two fractures, two enlarged glands, one teratoma, one endothelioma, one case of emphysema, one gumma, one enlarged thymus gland, one case of edema, one abscess of the thymus gland, and one diaphragmatic hernia.

History.—Probably the first to write upon mediastinal diseases was Van Switten, during the early part

of the seventeenth century. Since then until 1888, when H. A. Hare presented his Fothergillian essay in which he tabulates 520 cases of mediastinal affections, surgery of this locality has received but slight recognition. From this prodigious compilation much of our information is derived, and our deep appreciation is herein tendered.

Hippocrates and Galen were familiar with disease and injuries of this locality, but it was not until Velpeau (1754) that anything surgically is mentioned. He removed a portion of the sternum for caries. It continued to be a forbidden field for the surgeon for many years, until Hayfelder (1862) collected twenty-five resections of the sternum. Twenty-two were for caries, two were compound fractures, and one was done for exostoses. Of this number only two died.

Velpeau was the most frequent contributor to this series. The most remarkable work was done by Kalaczek, who resected a portion of third, fourth, fifth and sixth ribs for enchondroma. The patient made an uninterrupted recovery.

Injuries to, and foreign bodies within this space, were no doubt first to receive attention from the surgeon, because they were of an emergency character.

The conclusions drawn from Hare's work corre spond with those of more recent date.

Since the year 1888 about 500 papers have been written upon injuries and diseases of this locality; with the exception of 42 on diagnosis, 7 on anatomy, 41 on pathology, and 144 on tumor (making a total of 234), the character of the lesion in more than 100 was some form of sarcoma, 40 dermoids, 36 abscesses, 11 carcinomata, 13 tubercular thymus glands, 4 hydatids, 3 cases of mediastinitis, 14 cysts, 9 cases of syphilis, teratomata 4, hemorrhage 4 cases, emphysema 3 cases, endotheliomata 3, embryomata 2, actinimycosis 1, gangrene 1, lipoma and foreign body 1 case each.

There have been 42 papers written during the last twenty years upon the surgical aspects of these lesions, more than were written before 1888. Twenty-one of this number state the character of the lesion for which

the operation was done, while the remaining are classed as miscellaneous.

Of the number of operations, ten were performed for abscesses, six for dermoids, three for wounds, one for a lipoma, one for the removal of a foreign body.

The methods resorted to, to accomplish this, were: Osteo-sternal flaps ten, trephine two, injections one, latero-posterior incision one, and not stated six. While these tables are necessarily more or less imperfect, they indicate facts that can not be obtained in any other way.

The deductions drawn from them are, in a measure, conclusive, at least sufficiently so to form a basis on which surgical principles may rest.

The first conclusion is that the following conditions are amenable to surgery, while those not included are more or less, or not at all, influenced by the X-ray, sero or chemico-therapy. The following conditions are operable: Abscess, dermoid, lipoma, foreign bodies, hemorrhage, enchondroma, serum, hydatids, gangrene, fibroma, tuberculosis, emphysema, diaphragmatic hernia.

Operation is also justifiable for injuries, fractures, depressions, caries, punctures, and exploration.

Probably 80 per cent of diagnoses on intra-thoracic diseases are errors. It is therefore assumed that but 20 per cent are correct. At any rate it is apparent that the increased uncertainty in the diagnosis of intra-thoracic diseases is especially encountered in endeavoring to determine the character of neoplasms during the first stages of their development. This uncertainty will to a great extent be overcome by the use of the X-ray, and exploratory operation, which is now made possible by intra-tracheal insufflation, which must be accepted as the safest, most efficient and practical means of exposing the intra-thoracic viscera for diagnosis and treatment by the application of surgical principles. The apparatus is simple, light in weight, portable, and can easily be constructed by any one of even slight mechanical ingenuity. Matas and Saurbruck's pressure-box was the first step to overcome pneumothorax with mechanical means, and while not

practical, it gave the impetus to the discovery of something more practical. There has been but little accomplished with this box that was not done before its discovery.

Surgery of the mediastinum has been principally confined to animal experimentation. It will not become generally applied to man until a more perfect technique has been developed, though it is now apparently safe. However, it must be remembered the sixty or seventy recorded sternal and mediastinal injuries and diseases operated upon have been done without any device to overcome pneumothorax.

With but three or four exceptions they were confined to the anterior portion.

It is thus proven that surgical invasion of this cavity is not as dangerous as it has been accredited with being.

Of the four divisions, the middle and posterior are the most difficult to approach with safety, while the superior is second to the anterior portion in safety.

By means of the technique for opening the mediastinum of the dog with the Meltzer and Auer apparatus modified by Quinby, the pneumothorax may be overcome so that any of the organs or intra-thoracic viscera may be attacked surgically for any reasonable purpose or time. The method of intra-tracheal insufflation surpasses in simplicity and effectiveness any yet devised. Ether spray mixed with air is introduced into the lung through the trachea with a foot-bellows maintaining a pressure of from 8 to 10 mm. of mercury. A case of a dog reported having survived ether anesthesia for twelve hours by this method is sufficient evidence to justify its continued use for experimental purposes. Thirty or forty grains of chloretone injected into the peritoneal cavity, or thirty minims of a saturated solution of curare given subcutaneously, may be substituted for ether to deaden sensibility.

Chloretone is one of the most desirable general anesthetics for experimental purposes where the life of the animal is not to be preserved. The anesthetic dose so nearly approaches the fatal dose that it can not be used with safety. Thirty, forty or fifty grains dis-

solved in four drachms of warm olive oil, injected into the peritoneal cavity, will cause sufficient anesthesia to perform any surgical demonstration upon the thoracic viscera. Occasionally a few inhalations of ether will be necessary to complete the work, especially if prolonged beyond thirty or forty minutes, should the animal survive the dose.

Curare is a very unstable product. Its value can not be too highly lauded in experimental surgery of the chest, but its effects can only be determined by actual experiment with each preparation.

ANATOMY.

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Diagnosiss of mediastinal pathology is more perplexing than that of any locality within the body for surgical purposes; but while this has been so, there is now hope that such difficulty will be overcome by means of the Roentgen ray. This, together with inspection, percussion, and auscultation, offers the only means of determining the presence and location of foreign bodies, neoplasms, fluids, and the anatomical relations of the mediastinum without opening the cavity by puncture or osteo-plastic flap, which will not only determine the presence of the pathological condition, but also its character, all forms producing much the same symptoms.

(b) *Forme des tumeurs du mediastin.* A bronchial cancer, it being indifferent of what order the bronchus

may be, whether large or small, has two main preformed routes of extension at its disposal. The easiest and most natural, and the one that is in the majority of cases first resorted to, is along the bronchial ramifications and the peribronchial tissue into the interior of the lung.

The Oliver-Cardarelli symptom.—Downward tug by transmitted impulse of larynx and trachea, when the head is slightly thrown back, may assist in the question of aneurysm of the aorta.

In carcinoma the characteristic cells in the sputa may settle the question.

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Treatment may be surgical, chemical, sero-therapeutic, or radiographic, singly or combined.

Surgical treatment probably originated in traumatic conditions, such as fractures, depressions and disease of the ribs and cartilages. Galen trephined the sternum for depressive fracture and the removal of fluid.

Technique.—Conditions may arise within the mediastinum that will necessitate surgical intervention. Topographically the mediastinum is divided into four spaces, namely: superior, anterior, middle and posterior. Several methods have been devised by which either one of these may be exposed sufficiently to examine any of the tissues, to remove foreign bodies, neoplasms or fluid of any character contained within them.

The superior space should be entered through the soft structures of the root of the neck.

The anterior.—Christian's table shows forty cases of dermoids and teratomata removed from this space. Trephine or resection of the sternum in part or in its entirety are preferable for exposing it, to render the area accessible. The ablation of the costal cartilages does not delay primary union. Large openings enable the heart to be manipulated without pulling or bending of that organ. A transverse sterno-thoractomy will expose the root of the large vessels as well as give entrance into the anterior and posterior chambers with less danger. After bilateral ligature of the mammary artery, the sternum is divided from behind with a Gigli saw, and the transverse incision extended on either side into the intercostal muscle-tissue.

The posterior mediastinum may be entered by a subperiosteal resection of one or more ribs posteriorly, or of a transverse process of a vertebra and displacement of the pleura. A transverse sterno-thoracotomy may also greatly facilitate entrance into the posterior space.

To approach the bronchi and esophagus the patient is placed prone. The incision is begun on the third, preferably upon the right side, three inches distant from the vertebral column, carrying it down to the

sixth rib and transversely to the spinal column. The ribs are thereby exposed and resected subperiosteally, the transverse processes of the vertebræ being also resected. The esophagus is then readily exposed and a bougie introduced through the mouth and esophagus (Ransohoff).

The middle.—This, next to the anterior, is the most available in which to do surgical repair. The two are usually involved together and are approached in much the same way, through the anterior and posterior openings in the thorax.

Transverse sternothoracotomy better facilitates the entrance into the anterior and posterior mediastinum than any other method. The dangers are lessened and repair is more rapid and perfect. This is accomplished by a transverse incision through the overlying soft structures corresponding to the second intercostal space, proximal and distal ligation of both mammary arteries and division of the sternum from behind with a Gigli saw.

X-ray and radiography have become important factors in dealing with various pathologic conditions found within the mediastinum. Foreign bodies, neoplasms, fistulas and fluids may be very accurately located.

The Roentgen ray offers in many cases, especially malignant growths and simple hypertrofication of soft tissues like the thymus, lymphatic and thyroid gland, the only remedy.

Radium has been found by experiments upon lower animals and a few clinical cases to be of value, probably exceeding that of the X-ray.

Sero-therapy offers much encouragement and bids fair to become one of the most important adjuncts to the surgical armamentarium in treating neoplasms, and those intra-thoracic seem especially favorable.

SURGICAL INDICATIONS.

1. Injuries.
2. Foreign Bodies.
3. Mediastinitis—Suppurative, Non-suppurative.
4. Cysts, containing—
    a. Serum.

b. Chyle.
c. Blood.
d. Hydatids.
e. Dermoids.
f. Thyroid, or
g. Tubercular tissue.

5. Syphilis.
6. Actinomycosis.
7. Emphysema.
8. Gangrene.
9. Fistula.
10. Neoplasms—Non-malignant, Malignant—
    a. Carcinoma.
    b. Sarcoma.

Injuries may consist of punctures, lacerations, and may be caused by foreign bodies, and may vary in degree and severity; they are quite common, as are also fractures of the sternum and vertebræ.

Punctures are inflicted by means of sharp-pointed instruments, such as spears, darts and gun-missiles, each of which may completely or partially penetrate the space. Punctures may be complicated or non-complicated, usually complicated if due to fragments of ribs or vertebræ or when the cartilages, pleuræ, lungs or the pericardium are involved.

Lacerations are usually caused by ragged foreign bodies, such as pieces of wood or metal; such injuries involve especially the soft structures, such as the pleuræ, lungs and pericardium. They may be due to crushing wounds where the ribs or cartilages are fractured.

Foreign bodies, such as bullets, fragments of wood, metal, glass or porcelain, not infrequently lodge within the mediastinum directly from without, through the lung, esophagus or bronchus, or from the pericardial or pleural spaces after having remained there for a considerable time.

Cysts, serum, and pus.—Cysts may contain blood, pus, serum, or chyle, vary in size and originate in any of the tissues entering into the formation of the mediastinum directly or indirectly. When parasitic they are usually of the echinococcus variety. They may

remain sterile, inactive, or become acutely infected at any time. If small, not infected and causing no serious symptoms, they need not be disturbed, especially when absorption is evidently taking place.

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Mediastinitis may be primary or secondary, primary resulting from wounds and secondary from intrathoracic infection.

Mediastinal Pleurisy, Serum.—Frick remarks that the clinical manifestations of mediastinal exudative pleurisy differ according to the part of the mediastinum exposed to pressure. For this reason three different forms of mediastinal pleurisy are to be distinguished: 1. Pleuritis mediastinalis anterior sinistra; 2, pleuritis mediastinalis anterior dextra; 3, pleuritis mediastinalis posterior. This distinction is justified, not merely from an anatomical point of view, but because it corresponds closely to clinical facts. Pleuritis mediastinalis anterior sinistra resembles very much exudative pericarditis. The most striking symptom of a pleuritis mediastinalis anterior dextra is very deep cyanosis of head, neck, thorax and upper extremities. A posterior mediastinal pleurisy will, provided the exudate is deeply situated and is sufficiently large, cause inspiratory stridor, and sometimes a deviation of the trachea by pressure on the trachea, dysphagia by pressure on the esophagus, engorgement of the intercostal veins by pressure on the azygos veins, and par-

oxysmal cough by pressure on the pneumogastric nerve.

Mediastritis suppurativa, one case, incision through the right seventh intercostal space.

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SUPPURATING MEDIASTINITIS.

Basquet (1889) drained by incision an abscess of the anterior mediastinum, and Fromaget (1891) made a tracheotomy to prevent suffocation from pus-pressure in the mediastinum. Bruen (1891) records a case of rupture of a mediastinal abscess into the lung, and Razumovski (1899) an abscess in the posterior mediastinum due to gunshot-wound of the esophagus. Drainage, recovery.

The condition may be due to disease or injury of any of the soft or hard tissues entering directly or indirectly into the formation of the mediastinum, any one of the four divisions may be partially or completely occupied, but the superior is less frequently involved.

It is of frequent occurrence, and generally in the anterior portion, usually following injury, such as penetrating wounds, fractures, or it may be secondary to disease of adjacent structures, of which pericarditis

is the most frequent. The pus may be removed through an opening in the sternum by trephine or resection of the sternum. Such wounds are complicated.

Acute abscess occurs as frequently in the anterior mediastinum as in all other localities within it, as shown by 115 cases tabulated by Hare, who concludes that it is most common about the age of thirty years, or dividing the period of from twenty to thirty years of age. Abscess due to foreign bodies in the esophagus is quite frequent.

SUPPURATING.

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Serum-like fluids of various kinds may form within or enter from without the mediastinum. They may vary in density, amount and duration, and become absorbed, infected or remain indefinitely without causing much disturbance, unless large in amount.

Chyle has been found within the mediastinum in considerable amount, having escaped from an opening in the ductus thoracicus or its branches. It may become absorbed after spontaneous or surgical closure of the opening, or it may be infected and remain indefinitely. Rupture into the pericardial, pleural or peritoneal cavity or its disturbance may necessitate artificial removal.

Hemorrhage may originate from the inner surface or wall of the mediastinal space, or it may occur through the wall of the latter, the blood having escaped from the heart, pericardium, lung or elsewhere, but unless the quantity be sufficiently large to cause pressure-disturbances there may be no occasion for removing it. If, however, for any reason it has been removed by trephine or resection of the sternum, the wound at once becomes complicated.

Hemorrhage into the mediastinum alone does not occur frequently, though it may be the result of injury or disease of any of the soft or hard tissues entering into its formation. It may be slight or severe, slow or rapid, and escape into the pleural, pericardial or abdominal cavity, or the esophagus or bronchus.

Coagulation may occur with subsequent absorption, or infection may result in the formation of pus within one or more of the four divisions.

Hematomata occur equally frequent in the anterior and posterior spaces, and trauma is their most common cause. The male is therefore oftener subject of this condition. Hare states, 1888, p. 120: "Even when their position and existence is thoroughly established they should not be operated upon other than by thoracentesis, and even this measure is open to the grave objections that the removal of the pressure may, in

the acute variety, precipitate a fresh hemorrhage, or, in the second form transform a passive oozing into a torrent of blood. This measure should therefore only be resorted to when, as already stated, the diagnosis is thoroughly established and the patient is so near death from pressure-symptoms that any chances for his relief are to be taken." This statement can now be questioned with considerable propriety. Such a doctrine should not find a resting-place.

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Hydatid cysts in the mediastinum are exceedingly rare, only four cases having been recorded before 1888. This is especially interesting when compared to their frequent occurrence in the lungs and circulatory system, and that all reported cases occurred before the middle age.

The treatment of mediastinal hydatid cysts, like those of the dermoid variety, is comparatively favorable, especially those in the anterior space. The evacuation of the cyst by trocar or incision, and various other medicated solutions, has been suggested, but more radical measures may now be resorted to with equal safety and with more favorable results by thoracoplasty and drainage.

HYDATID CYSTS IN THE MEDIASTINUM.

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Dermoid cysts are second in frequency to malignant growths, but unlike them are one of the most favorable types of neoplasms found within the mediastinum for operation. They rarely occur in the mediastinum, as but ten such cases have been recorded prior to 1888, each of which was located in the anterior portion of

the space and occurred in individuals beyond twenty years of age. They originate embryologically, and this locality is the fourth favorable place for their growth in the human body. Their locations in the anterior portion of the space renders the removal of such cysts more favorable than if located in the middle or posterior portion. They are favorable because cystic and accessible for removal and drainage.

Dermoid cysts are congenital and may remain unrecognized. Carpenter (1906) discovered one in a child two years old. They are by far more frequent in the anterior mediastinum and may become infected, or rupture, at any period of their existence, into the pericardial, pleural or peritoneal cavity, esophagus, bronchus or cardio-vascular system. They usually become infected whenever this occurs, and they may become so if it does not occur. Seldom, if ever, do the solid contents escape without surgical assistance.

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Thyroid cysts are not infrequently found in the superior mediastinal space, and they may be single or multiple, vary in size, character, consistency and location, even to encroaching upon the anterior and superior spaces. Such goitres are termed Diving Goitre (Malard, 1879), Endothoracic Goitre (Cadet, 1905). Ricketts, B. M. (1895), operated upon a male about thirty years old for such a cyst, and (1904) another in a female forty years of age. Pressure symptoms were alarming in each patient, but immediately disappeared after operation. Recovery uneventful in each case. Since writing this chapter he has removed another large cyst of the thyroid lobe, in a male thirty years old, occupying a space behind the innominate artery and arch of the aorta; recovery; operation, April 16th, 1913.

THYROID CYSTS.

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Tuberculosis appears in the form of caseous deposits, usually with secondary glandular degeneration, but it may be primary. When secondary, it is by extension from the pleura, pericardium or lung, and any one of the four divisions may be equally involved in frequency or extent, but that of the anterior chamber probably is more frequently affected. The primary or secondary lesion may become associated with pus at any time.

TUBERCULOSIS.

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Liefmann, E.: Centralbl. f. allg. Path. u. Path. Anat., Jena, xv, 749-751, 1904.

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Syphilis occasionally manifests itself in the form of gumma, independently or associated with a lymphatic or the thymus gland, pleura, lung, pericardium, cartileges or bony structures. But five such cases, however, have been reported in this series. There does not seem to be any special locality in which it is more liable to occur. Mercury, saltarsan, or potassium iodide should be given to the point of ptyalization or maximum dosage.

SYPHILIS.

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Milne, L. S.: Proc. N. York Path. Soc., n. s. ix, 66-73, 1909-10.

Actinomycosis of the mediastinum appears in literature as having occurred but once, though about 20 per cent of all cases occur in the lung. The head and neck are the most frequent points of election, 50 per cent of all cases in the body having been found there.

Symptoms when found in the lung are pain followed by pleurisy and expectoration, pneumonia or bronchitis, or both. At this time there occurs proliferation of round cells which soon undergo fatty degeneration and abscess which ruptures into the bronchia. Examination of the pus shows yellow sud-like bodies visible to the eye, and when they are rubbed between the fingers they give a greasy feel.

Treatment.—Daily large doses of iodine of potassium internally and a one per cent solution subcutaneously in one-half drachm doses every third or fourth day. Five per cent solutions of carbolic acid, permanganate of potassium and methyl-violet have also been given in this way.

Von Schrotter, L.: Ueber Actinomycose des Mediastinums und des Herzens. Internat. Beitr. z. Inn. Med. (Leyden), Berl., i, 535-555, 1903.

Emphysema may result from direct injury to the chest, especially when the thoracic wall is penetrated, or the lung, trachea, bronchus or œsophagus have been perforated from any cause. It may remain localized, or extend to involve the entire body.

Technique of Operation.—An incision is made in the lower neck or chest, or both, or what is probably better, alone or combined with these, a tracheotomy is done through which a cannula is introduced to within one-half inch of the bifurcation of the trachea. In great emergency-cases these incisions should be made as rapidly as possible, sometimes without pulmonary, sometimes with local anesthesia. Great care should be exercised in keeping the tube free from mucus, by frequently withdrawing and cleansing it; better still, a second tube should be ready to replace the first.

EMPHYSEMA.

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Graeve, O.: Ueber interstitielles Emphysem der Lungen und des Mediastinum. Kiel, 1899.

Perrin, P.: Arch. de Med. et Pharm. Mil., Par., xl, 409-411, 1902.

Gangrene rarely occurs within this locality; however, it may do so, resulting from trauma, or any pathological organism. The case of Neveux (1895) had its origin in the lung, but gradually encroached upon other tissues within the space. It may be primary or secondary, primary when it originates in a new growth that is located within the mediastinal space, secondary when it encroaches upon the space indirectly.

Treatment consists in thoracoplasty and removal of as much of the pathology as possible. Drainage is the most important element in the treatment.

Neveux, G.: De la gangrene du mediastinum et de la gangrene pulmonaire consecutive, Paris, 1895.

Fistulae may be single or multiple, due to injury or disease, and close spontaneously by surgical operation or the injection of bismuth paste. They may originate

in the esophagus, bronchus, or any of the soft structures surrounding it. They may also result from disease of the vertebræ or soft structures of the neck, or foreign bodies entering from without, or concretions forming within the thorax. They are always infected and remain so until closure.

NEOPLASMS—BENIGN, MALIGNANT.

Neoplasms are found more frequently in the anterior mediastinum, and may be either malignant or non-malignant. If carcinoma, it is usually secondary to carcinoma in the mammary gland. Nothing can be done for malignant cases that will be of any benefit, but when non-malignant they may be removed by an osteo-cartilaginous flap, consisting of the sternum and costal cartilages. Drainage should always follow such operations, with or without infection.

Sir Richard Douglas Powell (The Practitioner, lxxxvi, 605, 1911): Mediastinal growths are, in practice, comparatively rarely met with, so that their occurrence is apt to take us by surprise. Further given a mediastinal growth as a certain diagnosis, the prognosis is absolutely fatal.

About 90 per cent of the cases of intra-thoracic growths are of malignant nature, either in the form of carcinoma or sarcoma. Hydatids, enchondromata, fibromata, are comparatively rare. Growths in the medistinum are generally but not by any means always primary. Sarcoma and lymph-sarcoma are the most common growths in the mediastinum, true carcinoma being comparatively rare. The most common seat of the original growth is in the lymphatic glands of the upper mediastinum. Malignant disease may extend into the mediastinum from different parts, more particularly from the esophagus.

Powell, in speaking of the treatment of mediastinal growths, remarks that we can do something in palliation. One point to consider in a great many cases is, what to do with the effusion. If we recognize that effusion is a consequence of a growth—as we commonly do upon the first tapping, for instance—we will

postpone a later tapping as long as we can consistently, without aggravating the distress of the patient.

Undoubtedly the pressure of a fluid effusion somewhat retards the activity of a malignant growth. From the same point of view, when tapping such a case, we would not completely exhaust the pleura, but only draw off that amount of fluid which would give relief, because if we produce a negative pressure in the chest we would be liable to induce some hemorrhage, or at all events we would aspirate the blood towards the growth and increase the rapidity of its formation. For the dyspnea in these cases we may use oxygen inhalations. In such a case one would only use oxygen from time to time, in so far as it might relieve suffering. The pain in these cases, which is generally considerable in the earlier stages, can be relieved by the use of morphine. In a later stage it is distress and dyspnea from which they suffer rather than pain. There is one combination of drugs which Paneill has found useful in these cases, especially in the early stage, namely, a combination of sodium iodide and chloral. Two or three grains of sodium iodide and five or seven grains of chloral, given every three or four or six hours, undoubtedly do give relief to the dyspnea. Possibly the iodide has some effect in causing the absorption, not of the tumor, but of the adventitious materials about the tumor, while the chloral is a valuable sedative and antispasmodic. Produce sleep with chloral or opium.

Hinman: "A correct diagnosis of mediastinal tumor usually can be made from the physical signs and symptoms described. Whether the tumor be benign or malignant can only be determined by a consideration of the course of the disease and the character of the onset. If these indicate malignancy it is in all probability a sarcoma. A tumor of slow progress indicates a dermoid. Cachexia is rare from dermoids. Sarcoma rarely gives symptoms longer than one year, while the dermoid has a duration of from three to ten years. The pressure signs, such as edema, inequality of pupils, cyanosis, laryngeal symptoms, etc., are rarely present in the case of dermoids, except in those which show

malignancy. The sputum should be carefully watched if dermoids are suspected. When hairs are expectorated the diagnosis is assured. A fistulous communication with the skin should be studied as to the nature of the discharge. The discharge of hair gives a certain diagnosis of dermoid. Fat droplets, fatty acid or cholesterin crystals or squamous epithelium in the sputum or escaping from a fistulous opening are very suggestive of dermoid.

"*Aneurism is often difficult of differentiation.* The time element is important. The signs of pressure are as a rule more marked in a tumor. Tracheal tugging is rare in tumor. The radiograph furnishes very valuable information both as to the presence and the differentiation of tumors in the mediastinum.

"*Differential diagnosis from tumors of the lung* offers the greatest difficulty because they invade the mediastinum early. A history of onset with cough and blood-stained sputum, without signs of pulmonary tuberculosis, is very suggestive of lung tumor, particularly if occuring in a person over fifty. Hemoptysis is fairly common with dermoids and teratomata, but these tumors usually occur before the thirtieth year.

"*Acute and chronic mediastinitis* are practically never primary, but occur secondarily to neighboring infections and may give no differential signs or symptoms. When the process, however, has gone on to the formation of an abscess in the mediastinum, pressure-symptoms develop and might lead to confusion with a simple tumor if it were not for the train of symptoms indicating a septic process. The throbbing thoracic pain, the fever, rapid pulse and facies of a septic condition have a very definite differential value. The conditions of intra-thoracic goitre, mediastinal hernia and mediastinal emphysema are rare and need scarcely be mentioned."

Fibroma is less frequent in this space than the preceding neoplasms, and has not been found to be multiple and the single growth never attains any great size. It occurs more frequently in the male, and is rare in childhood. Being located nearly always in the anterior

portion, it is frequently amenable to surgical measures for its destruction.

Lipoma, especially of the multiple variety, is exceedingly rare, there being but one such case reported. This was in the anterior portion and no doubt could have been removed with a reasonable assurance of safety had its character been determined early enough to have afforded the advantages that intra-tracheal insufflation offers.

Bertoli, P.: Un raro caso di lipomi multipli sotto-pleurici nel mediastino anteriors. Gazz. d. osp., Milano, xxix, 1108, 1908.

Carcinoma occurs about seventy-five per cent as frequently as sarcoma, and as often in the anterior mediastinum as in all other locations, alone or combined, within the mediastinum.

One primary and two secondary instances of it have been found in the mediastinum.

NEOPLASMS.

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Edwards, W. A.: Carcinoma of the mediastinum in children; report of a case and reviews of the sixty-seven cases of mediastinal disease previously recorded. Arch. Pediat., Phila., vi, 450-467, 1889.

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Josephsohn, A.: Ein Fall von Carcinom des Mediastinums, Tubingen, 1895.

Von Baumgarten, P.: Ein Fall von Carcinoma des Mediastinums, Tubingen, 1895.

Takesaki, K. (Japanese text): Ztschr. d. Med. Gesellsch. zu Tokyo, xii, 261-272, 1 pl., 1898.

Simpson, W. K.: Tr. Am. Laryng. Ass., N. Y., xxv, 150-156, 1903.

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Von Eiselberg: Wiener klin. Woch., xix, 1903.

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Sauerbruch: Munch. Med. Woch., Nov., 1906.
Sears: Trans. Assn. Am. Phys., 1906.
Capps and Lewis: Am. J. M. Sc., Dec., 1907.
Beck: Surg. Dis. of chest, 1907.
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Christian: Osler's Modern Medicine, p. 892.
Tiegel: Muench. Med. Wchnschr., iii, No. 46.

The treatment after operations upon the mediastinum pertains principally to drainage, for there is not an operation in this space that does not require it. The body should be placed in a semi-recumbent position as soon as possible.

If the condition is aseptic the tape or tube should be inserted into the space and removed whenever the amount of secretion becomes minimized, but if such a secretion becomes septic the drainage should be permanent and the wound treated as though it had been primarily infected. If primarily infected the same provisionary drainage should be instituted, and the dressings changed daily, oftener if necessary. Dressings may be secured in place preferably by a muslin jacket.

SURGERY OF THE MEDIASTINUM.

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Ballance, C. A.: A case in which the gladiolus was trephined for pus pent up in the anterior mediastinum. Proc. R. Soc., Lond., xii, 8-15, 1888-89.

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Quena and Hartmann: Des voies de penetration chirurgicale dans le mediastin posterieur. Bull. et Mem. Soc. de Chir., Par., xvii, 82-85, 1891.

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Beatson: A fatty tumor removed from the superior mediastinum. Glasgow M. J., li, 57, 1899.

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Thorne, W. S.: Gaseous degeneration of the mediastinal glands, operation, recovery. Occidental M. Times, San Fran., xv, 88, 1901.

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Von Eiselberg: Zur Therapie der Dermoide des Mediastinum anticum. Verhandl. d. Deutsch. f. Chir., Berl., xxxii, pt. 2, 197-212, 1903.

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Von Elischer, J.: Weitere Beitrage zur Behandlung der Mediastinaler Tumoren mit Rontgenstrahlen. Deutche med. Wchnschr., Leipz. u. Berl., xxxiii, 505-507, 1907.

Schwarz, G.: Ueber einen mit Rontgenstrahlen behandelten Fall von Mediastinaltumor nebst Bermerkung uber den Ruckbildungsmechanismus bestrahlter Geschwulste. Wien. klin. Wchnschr., xx, 1468-1470, 1907.

Sarcomata occur about twenty-five per cent less frequently than carcinoma, and as often in the anterior mediastinum as in the posterior, anterior and middle, anterior and posterior, whole thorax, and middle mediastinum.

Sarcomata primarily or secondarily are the second-most frequent neoplasms of any character found within the mediastinal space. Of its many varieties there are probably none that have not been discovered there either primarily or secondarily, but sarcomata are more frequently secondary and the lung and pleura

the seat of their origin. That the thymus gland or its remains are frequently their seat of origin there can be no doubt. Sarcomata have been found to originate in the pericardium, heart, trachea, esophagus, bronchus, thyroid, sternum, diaphragm, ribs and vertebræ, and in both animal and man alike, though with not the same frequency in the lower animals, in which it seems to have a predisposition to the carnivoræ, especially the dog and rhinoceros.

Hodgkin's Disease.—Pseudoleukaemia, or Hodgkin's disease, a communication concerning which we publish in the same issue of the N. Y. Med. Journal, is one of the most resistant to treatment of all pathological conditions. There is a suspicion that it is allied to the malignant neoplasms, yet arsenic, which according to Sir John Hutchinson, will give rise to cancer, seems to have produced the best results so far, if we except two somewhat obscure cases reported some ten years ago by W. A. Pusey, in which recovery is said to have taken place after persistent use of the X-rays. Iodine and potassium iodide are praised by some therapeutists and severely condemned by others. In following up the idea of the specificity of arsenic, sodium cacodylate and ataxyl have been tried and found wanting; they have been given internally and by injection. Applications of green soap and of solution of formaldehyde and rectified spirits have been made to the skin over the enlarged glands. Berberine hydrochloride has been exhibited. A list of the drugs tried seems to be mainly useful in stimulating the imagination of the practitioner who may be confronted with a case of Hodgkin's disease, so that he may strike out a new path in treatment and not waste time in repeating measures that have not produced a single authentic cure. Surgery seems to be equally helpless in the face of this baffling malady.

HODGKIN'S DISEASE AND PSEUDOLEUKAEMIA.

New York, May 30, 1911.

To the Editor:

The impression seems to be prevalent that Hodgkin's disease and pseudoleukaemia are identical, since the

terms are often employed interchangeably by medical writers. For example, in America such observant students of Hodgkin's disease as Longcope and Reed have fallen into this error repeatedly, while in an editorial in the Journal for May 20th, page 994, the titles in question are used synonymously. On page 972 of the same number of the Journal, however, the statement occurs in an article on Certain Lesions of the Lymph Nodes, that "pseudoleukaemia is to be distinguished from Hodgkin's disease, since the latter is associated with histological changes which render its recognition practicable in almost any circumstance." (Symmers.)

In this connection permit me again to point out that pseudoleukaemia and Hodgkin's disease are entirely different lesions, although sometimes resembling one another in their clinical aspects. Pseudoleukaemia was described by Cohnheim as a lesion presenting the essential anatomical changes of chronic lymphatic leukaemia (lymphomatosis), but without changes in the blood. On the other hand, innumerable investigators have shown that Hodgkin's disease is histologically separable not only from pseudoleukaemia but from the several other conditions with which it was previously confused. Thus, in contradistinction to the simple lymphomatosis of pseudoleukaemia, Hodgkin's disease is characterized, histologically, by overgrowth of interstitial connective tissue, by proliferation of endothelial cells and the formation of multinucleated giant cells, by the occurrence of variable number of lymphoid cells and eosinophiles, and, finally, by areas of necrosis —a composite picture sufficiently unlike that of any other known lesion to render its recognition relatively simple."—Douglas Symmers, M.D.

(If we erred in considering Hodgkin's disease to be identical with pseudoleukaemia, we erred in good company. Tyson, Osler and French, in their work on practice, McFarland and Adami, in their pathologies, Foster, Dorland, Gould, and the latest authority, Steadman, in their dictionaries, and, finally, the Index-Catalogue of the Library of the Surgeon General's

Office, give pseudoleukaemia as a synonym of Hodgkin's disease.—Editor.)

Endothelioma is a rare form of new growth closely related to the sarcomata in genesis, and sometimes resembling them in appearance, while some resemble carcinoma to a degree that it is impossible to separate them.

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CHAPTER XIX.

COMPLICATIONS ARISING IN SURGICAL CONDITIONS OF THE THORAX AND ITS VISCERA.*

Complications existing before, arising during or occurring after a surgical operation upon or injury to the thorax and its viscera, are so frequent and of so much concern that their most important features, with their symptoms, diagnosis and treatment, are considered somewhat in detail. They may vary in degree and number, and greatly embarrass the after-care.

The purpose is to fortify those to whom the after-care is delegated against any emergency that may arise, because it is impossible for the surgeon to give his personal attention at all times, and because the attending physician is not at all times willing, though competent, to give his individual attention to such work.

The X-Ray and Radium have been so enthusiastically recommended, alone or combined with surgery, in the treatment of all forms of neoplasms of the thorax and its viscera, that it is becoming that they be given favorable mention, even though their curative influence in these tissues has not been well established. Their use is especially indicated in the inoperable benign and malignant growths, and operable malignant growths, and though but little has been accomplished with either, the results warrant their continued and energetic use. Their technique can only be known to but comparatively few, for which reason they will not be herein considered.

Mercury and Iodine alone or combined being almost specifics for syphilitic lesions, should be given in some form or way after surgical operations for any such lesions in the thorax or its viscera. They are indicated

* An address delivered to the students of the American Medical College, St. Louis, Mo., January, 1912.

in operations and injuries of all kinds upon syphilitic and sarcomatous subjects, and should be given to the maximum influence by inunctions, hypodermic injections of gray oil or by the mouth or rectum. Such a course of medication will prevent delayed union of fractured ribs, costal cartileges or sternum, and cause them to become united after all other means have failed.

Salvarsan.—"Timeo danaos et dona ferentes" ("I fear the Greeks even when they are bringing gifts.")

This much lauded remedy is now upon the trial-sheet; what balance will be shown to its credit remains as yet undetermined. Surgical conditions in which it will be most appropriate have not yet been decided upon, if they are at all to be relied upon. It is hardly probable that mercury, which has for centuries claimed to be the only specific for any disease, will be lost in the shadow of one so recently discovered. However, time may verify every claim that has been made in its favor.

Serum alone or combined with surgery, or any other remedy, has been of but little if any avail in the treatment of any form of neoplasms of the thorax or its viscera. However, as surgery and its combined treatment for malignant growths in these tissues has failed of material accomplishment, it is proper that serum and all other supposed remedies for their cure should be applied in their after-care.

Complications: Pain, cardiac changes, respiratory changes, shock, unconsciousness, delirium, gastritis, fever, local sepsis, general sepsis, soiled dressings, hemorrhage, urine, coprostasis, bronchitis, pneumonitis, nephritis, endocarditis, pleuritis, pericarditis, meningitis, osteitis, choroiditis, and osteomyelitis.

Pain.

Pain, more or less severe, is usually present after surgical or traumatic injury, not always proportionate to the amount of tissue involvement, but varying with the character and amount of nerve-tissue implicated, especially in the cutaneous structures.

It should be given careful and immediate considera-

tion, because it is usually due to hemorrhage, position of the body, tight ligature or suture. In either case it should be relieved by removing the cause, if not by the administration of narcotics, such as codeia, morphia, opium or their preparations. Hyoscyamine, morphia and cactine are popular with the profession.

Narcotics are often necessary, especially when pain is not well tolerated, sulphate of morphine and codeine being the best of the many forms of opium. They should be administered hypodermically when possible, beginning with the minimum dose, one-eighth of a grain, increasing in frequency to meet the requirements. Their general effects, such as nausea, constipation, vomiting and checking secretions, are the chief reasons for not using them. However, there are cases where they are absolutely necessary, though the prolonged constitutional effects of the hyoscyamine, morphia and cactine are undesirable, which is the chief cause of their combination being so slowly adopted.

Circulatory Changes.

Cardiac changes, such as indicated by the radial pulse, are many times most certain and absolute indications of the patient's condition, and a feeble, intermittent pulse exceeding 120 per minute in an adult, at any time, but especially after an operation, should be carefully considered, as it is always undesirable and should give cause for much concern.

Respiratory Changes.

Respiratory disturbances may begin with, exist throughout the administration of an anesthetic, and continue for several hours thereafter, or they may begin immediately after removing the mask and continue indefinitely, during the conscious or unconscious state, while respiration may be increased or diminished in frequency and strength. It may be thoracic or diaphragmatic, regular or intermittent, each being more or less of diagnostic value.

The respiratory movements are always more or less accelerated in injuries of the chest, and for this reason cause considerable disturbance.

Shock.

Shock, with subnormal temperature, varies in degree and is usually due to accidental or surgical trauma, hemorrhage or general anesthesia, alone or combined. Sometimes it is due to the loss of blood, manipulation of the viscera, joy, fright, heat, cold, and draughts of air or water.

Symptoms are first manifested by a change in the facial expression, by contracted features, sickly-white hue of skin, thin, pale lips, cyanosed and cold body; great decrease in muscular activity, especially of the eyelids, which do not close; relaxation of sphincter ani; swallowing difficult; retention of urine; absence of coma, but mental sluggishness well marked.

The pulse varies from slow in mild to rapid in severe cases, when it flutters and becomes imperceptible, which indicates the severity of the case.

The temperature, which should be taken in the rectum, is usually below normal, with general cold perspiration due to relaxed openings of the sweat-glands.

Vomiting and return of color are indications of reaction.

Treatment.—The same principles of treatment apply to all. The body should be made dry, artificial heat being applied by means of water-bottles, sacks of sand, salt or other articles, or electric heat can be used, and friction, all with great caution.

Water heated to the degree of tolerance may be taken into the stomach when conscious; if not so, it may be placed there or in the rectum through a tube, to be repeated every hour; while auto-transfusion should not be resorted to, nutrient enemas should be given, and morphia in small doses, for stimulation, administered continuously, hypodermatically.

Unconsciousness.

Unconsciousness following general anesthesia usually lasts but a few minutes or hours, but in some cases it may extend over a period of twenty-four hours or more, depending upon the amount of shock, and in spinal anesthesia the amount of tissue destroyed.

One or two hours is the usual time-limit for ether,

chloroform, or alcohol, chloroform and ether, while with nitrous oxide or ethyl chloride it lasts but a few minutes. Hypnosis may be prolonged indefinitely, but with all, eternal vigilance should be the watchword with those who assume the post-operative care.

Respiration, temperature, urinary and alimentary secretions should be especially observed. While unconsciousness varying in time and degree is necessary in many cases, it must be admitted that it is attended with great anxiety and responsibility, especially when produced with H. M.C., because no outcry from pain (which is so often a warning of hemorrhage) can be made for several hours.

Treatment is most urgent and should be given with the greatest caution. The body should be kept straight upon a plane, garments loosened, face uncovered, and all wet garments and bedding replaced with those that are dry, after the body has been made so. The body should be kept in an even temperature (80° F.), without draughts, and artificial heat applied by means of hot water bottles, sand, salt bags, metal or porcelain substances, each of which should be used with the greatest caution. The electric pad is the most desirable because the heat can be applied uniformly, constantly and without danger.

Stimulation by one or more of the means indicated should be used with great care, especially alcoholic and the drug stimulants.

Stimulants do not hold an important place in the after-treatment of surgical operations upon the chest and its viscera, especially the heart, where they are contraindicated. The use of stimulants during surgical operations on these organs, or in their after-care, can always be questioned with considerable propriety. This applies especially to alcohol and other stimulants that may produce vomiting. Much can be said in favor of adrenalin and water, but concerning other drugs there is much doubt. The one of selection should be that most available and of a technique most familiar to those who are to employ it.

Means of stimulation.—Hypodermoclysis; proctoclysis: transfusion of blood; intra-venous injection; alco-

hol; adrenalin; electricity; oxygen; divulsion of sphincter ani muscle; cardiac manipulation; digitalin; strychnine; nitro-glycerine, and camphor.

Hypodermoclysis has been practiced for twenty years with most satisfactory results as a substitute for a loss of blood, and in cases of shock without loss of blood. It is most available and appropriate, however, in cases of shock due to loss of blood. One should be familiar with its technique, especially with reference to cleanliness, because of the frequency of infection and abscess beneath the point of puncture. This is a very undesirable complication and one that can be avoided if the one-half of one per cent. solution of sodium chloride, the tubing, vessel and needle are sterilized, and the cutaneous structures of the operator and patient made clean. The elevation of the vessel should not exceed six feet, and the parts into which the injection has been made well massaged. One or two pints may be introduced through one puncture, more than this if necessary, with several punctures in the mid-axillary line over the scapula, into the loin or anterior thigh.

Proctoclysis is probably the best means of introducing large amounts of aqueous solutions into the body slowly for stimulating purposes for shock or infection. The receptacle should not exceed eighteen inches elevation, and the solution introduced by the drop method at a temperature corresponding with that of the body. Ten or twelve quarts may be introduced into the body within twenty-four hours, the amount depending upon the weight of the body and the purpose for which it is given. A No. 10 soft rubber catheter introduced into the rectum, and secured to the inner thigh with adhesive plaster, may remain without producing irritation of the ano-rectal or rectal mucosa. The clip may be adjusted to the rubber tubing so that the solution may flow at any rate, usually one drop per second being sufficient. At this rate about eight ounces are introduced into the rectum per hour or twelve quarts every twenty-four hours.

Transfusion has been practiced for thirty years, but not until recently has the technique been sufficiently perfected to make it at all popular. The best results

have been obtained in hospital practice, because of the great difficulty in applying it in private homes. There can be no question as to the benefits to be derived from it, and when properly done it is superior to any other means of introducing fluids into the body as substitutes for blood. It is not only superior for shock from loss of blood, but for anemia due to any cause; it is hardly advisable, however, unless the operator is thoroughly familiar with its technique. For this reason it will probably be some time before it is adopted for general use.

Intra-venous injection is the most direct and efficient way of supplying the body with fluid when indicated, as in shock or loss of blood, because any vein may be used, but those superficial are most available. One-fortieth the weight of the body, or 25 per cent. of the normal amount of blood in the body may be replaced with water containing one-half of 1 per cent. of chloride of sodium; usually only one-half this amount of the solution will be required, and should be given under strict aseptic precautions by one experienced in the art.

Alcohol has been employed as a stimulant from time immemorial, and it has been the most abused of all stimulants. There is much doubt as to it being of any value, and when given it should be per rectum when possible and with great caution.

Adrenalin is the most active and desirable cardiac stimulant for immediate use, and should be used with the greatest caution, and only by those who are familiar with its action. It is especially indicated in cardiac failure and vaso-motor paralysis occurring during the administration of general anesthesia, with and without loss of mental consciousness. Not more than five drops of a 1-1000 solution should at first be given, but this may be repeated within five minutes, or the second or third dose can be increased to ten, fifteen or twenty minims. Rarely is it necessary for more than fifteen minims to be given at the first injection, though as much as 2 c.c. have been given at one time. It may also be administered internally in the same dosage.

Electricity.—Interrupted faradism is beneficial as a

stimulant when properly applied; cumbersome apparatus and inexperience in its use are the chief reasons for its not being more frequently employed.

Oxygen has been used for twenty-five years as a stimulant for shock, and where the lung-capacity has been diminished from any cause; while it is not always available, it can be had in the larger cities and hospitals. It is becoming more generally used, and better understood, and should be found in the possession of all practitioners, because it can be kept indefinitely in cylinders for that purpose.

Divulsion of the sphincter ani muscle for immediate stimulation is the simplest and most available of all, and can be done by any physician, care being exercised, especially in the aged, to dilate gradually without tearing the muscular fibers.

Cardiac manipulation through the chest or abdominal wall is performed after the heart has ceased to beat, in a certain number of cases because it has been demonstrated that the heart may be resuscitated after two or three hours of quietude. The longest time of cardiac quiescence with permanent restoration of the heart-beat is twenty-one minutes, thus showing that this is one of the most desirable means for stimulation and resuscitation.

Digitalin, once a popular and favored cardiac stimulant, can no longer claim such prestige, because it has been found to have been overestimated for such purposes.

Strychnine has declined in popularity so much that it can hardly be recognized as an efficient cardiac stimulant; amounts sufficient for this purpose are too dangerous to tolerate and its use can not therefore be sanctioned.

Nitro-glycerine is too unstable and uncertain in its effects to be considered a reliable means for stimulation, because age, exposure to light and heat, cause it to deteriorate. Its effects are exceedingly short in duration, and, this being so, probably renders it more injurious than beneficial.

Stimulation by other means than those herein mentioned has been advocated at various times, but results

from the use of them do not warrant a further discussion of them here.

Intra-tracheal insufflation has been recommended as a most desirable and efficient means of resuscitation.

Delirium.

Delirium, mania or undue excitement may be due to cerebral anemia or infection, and they may last for hours, days or weeks, with complete loss of co-operation, which adds to the seriousness of the condition. The normal nervous and mental state should be re-established as soon as possible.

Treatment.—Great surveillance should be practiced —if necessary, even forcible restraint, that bodily harm may not occur. The treatment for cerebral anemia is the administration of sedatives by the mouth or rectum in sufficient quantities to control. When due to infection large quantities of water should be given by the stomach or rectum daily; if necessary, sedatives may be given likewise. In the more severe types it may become necessary to resort to the use of straps for confinement, food being given at regular intervals through a tube introduced into the stomach or rectum, the urine being evacuated every six or eight hours with a catheter, the body sponged once or twice daily, and the bowels evacuated by means of enemata or laxatives every forty-eight hours, oftener if necessary.

Sedatives are not often indicated, but may be beneficial in the highly nervous state which sometimes exists before or after operation. The bromides of potassium and strontium are probably the best, though chloral is used extensively. When indicated they should be given in twenty to forty grain doses, by mouth or rectum, well diluted, by the stomach when tolerated, by the rectum when not, every three or four hours, as the case may require.

Gastritis.

Gastritis, nausea, and vomiting frequently accompany and follow the anesthetic state; sometimes the stomach is dilated or distended with gas or fluid, or both. There may be acute gastritis alone, which, if

continued for any great length of time, may result in serious complications.

Treatment.—When they exist, a tube should be inserted into the stomach and the stomach thoroughly irrigated with two or three quarts of warm water, to be repeated if vomiting persists. Sometimes quiet, sponging the face and hands with ice water, ice packs on the throat, or crushed ice internally, will modify or prevent it. Usually nothing whatever should be taken into the stomach for twenty-four hours, but sometimes warm water taken in small amounts will prove beneficial; it may also be given per rectum. There are no known medicaments that are of any special benefit.

Temperature.

Temperature when above normal is physiological, and should not be interfered with by the administration of drugs. A rise of two or three degrees, with subsidence within forty hours, is due to reaction, and should not be disturbed; but if it continues beyond this time it should be carefully observed, because it is due to local or general infection from the wound, the intestinal or urinary tract, or to nervous irritation.

A post-operative temperature varying from normal to one hundred for several days should not be considered seriously, but if it continues beyond six or seven days its cause, if possible, should be ascertained.

Treatment.—Any medicament that will reduce temperature does so at the expense of the heart. It is therefore necessary to counteract its effects by a stimulant. Evacuation of the urinary and alimentary tracts is among the first essentials. Sponge baths with tepid water, followed by one of equal portions of alcohol and water, will also act as an antipyretic.

Antipyretics such as the coal tar derivatives have no place in post-operative therapeutics, nor have other medicaments employed for this purpose given internally or applied externally, because they have been the cause of many deaths and much chagrin. All are by far more harmful than beneficial and should be placed in the same category.

Tepid sponge baths are more pleasing and beneficial,

and when properly given with one or more degrees above the body temperature, at frequent intervals, are without danger. They may be followed with massage and applications of alcohol well diluted.

Sepsis.—(1) Local, (2) General.

Sepsis, whether local or general, immediately before, during or after thoracic surgery, is especially undesirable.

Local pertains to infection of the wound and its immediate surrounding structures, mixed or unmixed, mild or severe, and with or without rise of temperature, induration or odor. It may or may not begin with a chill, and with or without gastric disturbance, pain or discoloration, all depending upon the degree of severity and kind of infection, which is usually due to the streptococcus pyogenes citreous.

Symptoms are usually tenderness, induration, pain, redness, pus and slight rise of temperature, ranging differently in character and degree according to the nature of the infection.

Treatment consists in drainage, which usually necessitates the removal of one or all sutures. If the infection be but slight and the drainage be good, irrigation is not necessary; but if the infection be severe, with a large quantity of pus, drainage may be used to advantage. The wound should remain open, without any attempt whatever to close it with suture or strap, and the dressings should be applied often if necessary, depending upon the amount of discharge. It may be well to reopen the wound in its entirety after it has become fairly well united, or by an incision distant to the original wound.

General Sepsis.

General sepsis is a term applied to a condition of the body in which there is a general infection known as septicemia, usually resulting from retained blood-clots, serum, gangrenous or sloughing tissues. This septic condition must necessarily be local and general, and may vary in severity, depending upon its character.

Symptoms.—The symptoms of septicemia are constant, either in the mild or most severe type, and the

onset of the disease is gradual, with a rapid rise in temperature as the first indication. Unlike most other diseases that begin with a rapid rise of temperature, a chill rarely follows, but extreme prostration with headache, loss of appetite, and a marked indifference of the patient to his surroundings or his own condition soon are symptoms that become constant, even in the milder forms. In the more severe type these symptoms are exaggerated, and as the disease progresses other symptoms develop, due to the action of the poisons upon the blood, nervous system and intestinal tract.

Anemia is sometimes present, due to the absorption of the ammonia compounds; this condition, sometimes mistaken for shock, occurs but rarely, except in abdominal work.

Gastro-enteritis is a frequent symptom, varying in severity, and in the more severe forms rice-water stools and frequent vomiting are present.

Acute lymphangitis, with enlargement of the spleen, is usually present, and exists comparatively early in the disease.

Heart symptoms occasionally occur, and though no definite lesion is present, heart failure is the one thing to be guarded against.

Urinary symptoms are usually present late in the disease, the urine being concentrated and scant, and in the later stages almost entirely suppressed.

Skin.—In the early stages of sepsis the skin is hot and dry, due to the high temperature. There is also usually present a slight discoloration, probably due to the breaking down of the red corpuscles, and later in the disease the skin becomes bathed in perspiration, the icteric hue more pronounced and the facial changes characteristic.

Nervous symptoms are coma and delirium.

Treatment of any kind is very unsatisfactory, but nutritious food, with large quantities of water in the stomach and rectum, together with oxygen, are perhaps the most effectual means of sustaining life, the rectal method being an additional advantage to stomach feeding. If of the milder form, the removal of sutures, draining and cleansing of the wound, will often

be sufficient to check the progress of the disease. If, however, the most severe type (streptococcus pyogenes aureus), all efforts at relief are of but little avail, regardless of what is done with the point of inoculation.

Cellulitis is often the exciting cause for the primary operation, though it may develop at any time during convalescence. It is always the bane of the surgeon's existence, and should be cared for as his greatest and most dangerous enemy. Fortunately, it no longer holds high carnival in the surgeon's camp, being during these days of asepsis an infrequent visitor. All known precautions should be taken to prevent the spread of its contagion, isolation and drainage being two of the most important means. Pure carbolic acid applied to the reddened surface and three inches of its immediate border of skin normal in color, for two minutes, and then pure alcohol applied with pledgets for ten minutes, will sometimes check its progress.

Stimulants and nutritious food, plentifully taken at frequent intervals, are very essential.

Antiseptics in this enlightened day have no place in surgery, it being an impossibility to make the human flesh aseptic. While fabrics, instruments and paraphernalia may be made so with heat, the subject operated upon may himself have infected lymphatic glands resulting from pathologic tonsils, teeth, cutaneous or other tissues.

Many more lives have been sacrificed and convalescence prolonged by the poisonous effects of antiseptics than have been saved or shortened.

All corrosive poisonous antiseptics should be eliminated from the surgeon's paraphernalia. However, the skin may be made cleaner with chloroform, ether, benzine, gasoline, turpentine and alcohol after soap and water have been applied, especially for the removal of fatty substances.

Solutions, powders and ointments designed for so-called antiseptic dressings, should also be absolutely forbidden in the treatment of surgical wounds, or wounds that have been made surgical.

Soiled Dressings.

Soiled dressings, from any cause, demand as a rule immediate attention, for the soiling may be due to vomiting, blood, pus or serum, and many other causes; but when due to non-infected blood or serum they may remain undisturbed indefinitely. If they are hard and stiff, they should be replaced with fresh aseptic material.

Hemorrhage.

Hemorrhage is always to be feared, since it may occur immediately upon closing the wound, or at any subsequent time—with or without infection; it is prone to do so when virulent infection is present. A considerable amount of blood may escape into the pleural or pericardial cavity and remain unrecognized, or it may escape into the dressings or into the subcutaneous structures and there produce more or less distention. If, however, this tumefaction does not occur for several days, it may be due to the presence of blood, serum or emphysema, which should be removed at once.

Symptoms: When slight, but few if any manifestations may be present; but when more severe, there is pain if the blood is concealed. If not, it may be seen in the dressings. The pulse becomes more rapid and feeble and the facial appearance changes.

Treatment: If the hemorrhage upon the dressings is great in amount, its source should if possible be determined without reopening the wound. If this is not possible, the latter should be done at once. Tumefaction external to the ribs, without dressings being soiled, necessitates the removal of several cutaneous sutures, that the blood may be thoroughly removed. This accomplished, in the absence of a spurting vessel pressure will sometimes prevent further bleeding, but if blood continues to escape it will then become necessary to ascertain its source. If it be an intercostal or internal mammary artery, crushing with forceps will check it. The latter may remain in the wound for twenty-four or forty-eight hours. In the absence of forceps, a curved needle carrying a strong catgut ligature may be made to encircle both the distal and proxi-

mal ends, and should then be well secured by knots. Should the bleeding be from within the thoracic cavity its source would no doubt be one or more pulmonary vessels. This applies especially to pulmonary lesions, traumatic or surgical.

When the hemorrhage is external to this viscus and has been overcome, drainage is usually necessary. Primary union can not then be secured, especially not in the soft structures, if the time of reopening the wound exceed forty-eight hours after the primary dressing.

Urine.

Urine should be evacuated every eight hours, voluntarily or by catheter, with the usual precautions against infection. It should be examined at intervals of two or three days to detect, if present, any changes in the kidneys. If suppression of urine exists, every effort should be made to overcome it, by artificial heat to the body, large quantities of warm water taken into the stomach, or by proctoclysis. One or more of the various diuretics may be given by the stomach, the rectum or subcutaneously; the good effects of diuretics, however, are always more or less doubtful. The giving of one-half to one drachm of sweet spirits of nitre every half hour is sometimes attended with most gratifying results.

Coprostasis.

Coprostasis (Kop-ros-ta-sis)—"Stagnation of fecal matter, arrest of the onward movement of fecal matter." It may be due to constriction of the gut or to its inactivity. It is the latter which presents itself for consideration, and is quite common and more or less annoying, because of the disagreeable features of the administration of laxatives and enemas. The greatest difficulty is sometimes experienced in evacuating the bowel, even when constriction does not exist.

Laxatives.—Calomel, castor oil, sulphate of magnesia, cascara, enemata.

Treatment.—The bowels should be evacuated daily if necessary by means of mild catharsis or an enema, but in the most desperate cases it is better not to induce

stools too frequently unless obstruction or infection are present, then one-tenth grain of calomel with one grain of bicarbonate of soda given every hour for ten hours may be effectual. The first dose should be given twenty-four hours after the operation with an appropriate dose of sulphate of magnesia given two hours after the last dose of calomel. If the bowels are not evacuated satisfactorily within five hours of its administration, an enema of one or two quarts of warm water should be given. Castor oil (unrefined), when tolerated, is effective and should be used without any hesitancy in great amounts; as much as six ounces can be given at once, or in broken doses daily, without any injurious effects whatever. Croton oil is the most effective and should be more generally employed at any age.

Bronchitis.

Bronchitis, acute or chronic, more or less severe, may exist before, occur during or after surgical or traumatic injury. If during or after, it is usually due to the anesthetic, especially ether, which is more annoying in thoracic surgery, because of the distressing, painful cough and subsequent fatigue which it produces.

Symptoms.—Coryza is usually the first manifestation, followed by hoarseness, but rarely with a chill. Oppression is always present with pain in the bones and back; there is also tightness under the sternum, with little febrile disturbance when the attack is mild, but it may reach 103 degrees when it is severe. The cough has a metallic ring and is tight and dry at first, being without expectoration. As the disease progresses the cough loosens, and a considerable amount of mucopurulent material is expectorated, which in the latter stages becomes entirely purulent.

There is but little change in the character and number of respirations, unless the disease is severe.

Dyspnea is present when the small tubes are involved, so that bronchial fremitus may often be felt. Sibilant rales are present early in the course of the disease, but all of these physical signs change as the cough loosens.

Treatment.—In mild cases a hot foot-bath with hot drinks to keep the patient warm, will often be sufficient to overcome the disease. In the more severe cases codeine is very good for the cough, but, like morphine, it should be used with care in young and old. A sense of soreness and rawness in breathing is relieved by moistening the air with a spray consisting of carbolic acid, menthol, guaiacol, or inhaling carbonate of ammonia, either of which gives good results. When the cough loosens, an expectorant should be given; ipecac in small doses often being very effectual.

For a rapid heart, which is always present in severe cases, tincture of aconite should be given.

Pneumonitis.

Pneumonitis, or pneumonia, may result from aspiration of vomited material while under the anesthetic, or from trauma, surgical or otherwise, or infection from any cause. It almost invariably begins with a chill and involves all or part of one or more lobes.

Symptoms.—It begins with a chill lasting from five to twenty minutes, followed by a rapid rise of temperature, increased frequency of and painful respiration, and flushing of the face. The eyes are bright, the expression anxious, with dilatation of the alæ nasi during each inhalation. The expectoration is tenacious, viscid and tinged with blood. The pulse becomes full and bounding, so that its ratio to the respiration is disturbed, and as consolidation progresses blowing breathing and fine rales are heard.

The temperature subsides after the crisis and the facial expression changes to one of comparative comfort.

Defervescence may take place by lysis. There is fremitus with increase in the movements of the chest, less on the affected side, and the pulse is dicrotic.

Treatment by means of medication is of but little benefit, other than Dover's powder for sleep and alcohol and nutritious food for stimulation; oxygen inhaled frequently is most valuable for pneumonitis.

Of other drugs, digitalis, to support the heart, is indicated as a rule, and may be advantageously given

in the form of the U. S. P. infusion in tablespoonful doses every four hours. Potassium acetate may often be added to this infusion with great advantage, as this combination produces free diuresis, so often useful in heading off or ameliorating the next condition. We have to deal with nephritis.

Nephritis.

Nephritis may be present, or begin when the anesthetic is given, or it may appear at any time during convalescence and, varying in degree, may involve all or part of one or both kidneys. It is especially induced or aggravated by ether, and when present greatly complicates any form of injury.

Symptoms.—The amount of urine is usually increased, but it may be decreased and vary in specific gravity. There is lassitude, sleeplessness, gastric disturbance and headache, and later suppression and coma. Albumen is found in varying quantities, and the amount of uric acid excessive.

Treatment.—Quiet, regular and lax bowels, increase of the skin activity by warm baths and friction, the drinking of large quaitities of water, a light but nourishing diet, and total abstinence from alcohol, are the essentials.

Endocarditis.

Endocarditis may result from the effects of the anesthetic or any infection that may exist before, during or after the operation, or it may exist before or occur during or after surgical or traumatic wounds. It is the most dreaded of all post-operative complications associated with thoracic surgery, and is probably most often due to the anesthetic.

Symptoms.—There are none that are characteristic, but the number of the heartbeats is increased and its action is somewhat irregular, with murmurs accompanying the first sound, the temperature being slightly elevated. The diagnosis is difficult, probably never being certain.

Treatment consists in keeping the surrounding atmosphere at an even and uniform temperature. Rest, quietude and nutritious food are necessary. Ice-bags

over the heart will sometimes decrease the number of its beats.

Pleuritis.

Pleuritis is not infrequently associated with injuries and surgical operation upon the chest, and infection may exist before or after or coincident with it, varying in severity.

Symptoms.—Prodromes are not uncommon, but a chill may be the first manifestation; pain may be present early in any part of the chest or upper part of the abdomen, more frequently in the nipple or axillary line; it is sharp and severe, and aggravated by a cough.

Friction sounds may be felt or heard and the temperature may rise rapidly to 103 degrees and continue so for several weeks. During the earlier stages the expectoration is usually slight in amount, mucoid in character and finally streaked with blood, the affected side being immobilized and the intercostal spaces obliterated.

When the effusion is upon the right side, the apex-beat may be lifted to the fourth interspace or pushed to the left of the nipple-line, or even into the axilla.

Edema of the chest-wall is rare, but the intercostal spaces may be obliterated and fluctuation difficult to determine.

Tactile fremitus is greatly diminished or even abolished, and voice-vibrations are absent when the effusion is extensive. Resonance becomes defective, or there may even be dullness in the presence of fluid.

Treatment.—A recumbent position, liquid diet, mild purging, strapping the affected side, and morphine and leeching for pain, are probably the most beneficial measures. When effusion is present, counter-irritations are especially valuable in the later stages.

Pericarditis.

Pericarditis is one of the most serious complications to be encountered in thoracic surgery, and the anesthetic is its most frequent cause.

Symptoms are first manifested by pain varying in intensity in the pericardiac region and near the xiphoid cartilage, sometimes resembling angina, and the tem-

perature varies from 99 to 102 unless there be infection, when it may be higher.

Fremitus may be present as the result of the roughened surfaces of the pericardium rubbing upon one another with a grating sound unlike that of endocarditis; effusion may or may not be present, conditions which usually follow dry or plastic pericarditis respectively.

Treatment necessitates quietude both mentally and physically. Depletion in the robust, especially when pleuro-pneumonia is present, is sometimes beneficial; drugs are of but little if any benefit, but ice-bags to the precordium for an hour or so at a time at first, and then continually, with effusion, are sometimes of great value.

Meningitis.

Meningitis is not frequently associated with operations upon the thorax, unless it exists at the time the work is done. There is always more or less danger of infecting the cerebral meninges when tubercular lesions of the chest (especially of the lung) are treated surgically. The probabilities are that pulmonary anesthetics alone are more prone to cause it in this type of lesions, with or without operation.

Symptoms begin with a severe chill, followed by well distributed pain in the head. The temperature, which averages high, fluctuates more or less; there is opisthotonos, sometimes very extreme, and low muttering delirium.

Treatment.—There is not much to suggest in the way of treatment other than to supply nutrition in proper amount, ice-bags to the head, and frequent sponging of the body. The surgical measures are to remove the fluid from the cerebral cavities by trephining, or lumbar puncture and withdrawal of the fluid, especially if it be cloudy, turbid or purulent.

Chondritis.

Chonditis may exist before, or occur after operation, and involve the sternum or one or more costal cartilages, or both. It may be the indication for the primary operation, or the result of infection incident to,

or subsequent to it, and necessitate removal of a part or all of the sternum and costal cartilages.

Symptoms may be acute or subacute, beginning with or without a chill or rigors. The temperature usually varies from normal in the beginning to 102 or more degrees later on. It more frequently remains at about 100 throughout the acute stage, with more or less pain. The local symptoms are redness with considerable tenderness and induration extending over the entire affected area.

Treatment is purely surgical by means of free incision of greater or less extent at one or more points, depending upon the amount of tissue and area involved. The removal of all of the diseased cartilage, together with ample drainage, is essential to rapid and permanent repair.

Osteitis.

Osteitis is sometimes due to the primary operation, but it may develop as the result of infection at any time during convalescence and involve one or more ribs. In such a case caries results, necessitating the removal of the affected bone.

Symptoms may develop rapidly or slowly, usually slowly, beginning with or without pain, which is always present and more or less severe when the medullary body is principally involved. It then remains severe until the osseous abscesses are freely opened. The temperature usually follows a chill, soon after which there is acute tenderness, and a reddened tumefaction becomes manifest.

Slight delirium and loss of appetite occur frequently in the more severe forms.

Treatment can only be considered from a purely surgical standpoint. Free incision down upon and into the diseased osseous structures, with drainage, is the method of choice, and it should be resorted to as soon as possible after the lesion has been located. The necrosed bone should be thoroughly removed as far as possible at the primary operation, but it is often desirable to do it by means of a secondary operation after the acute symptoms subside.

Osteomyelitis is the most actively destructive and

dangerous of the acute inflammatory bone-lesions. It may involve one or more ribs, and be complicated with a degree of destruction of soft soft tissue sufficient to open the pleural cavity. It may not be recognized until considerable destruction has taken place, and hence is often mistaken for typhoid fever.

Symptoms are swelling, redness and pain, with fever running 104 degrees or higher; an abscess soon forms, through drainage of which, however, these symptoms at once abate.

Treatment is quick surgical intervention by incision and drainage. Excision of the diseased bone is probably better accomplished and with greater safety after the acute symptoms have subsided. Every effort should be made to keep the patient well nourished.

CHAPTER XX.

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